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The Osteocranium of the American Cyprinid Fish, *Notropis bifrenatus,* with an Annotated Synonymy of Teleost Skull Bones

ROBERT W. HARRINGTON, JR.

INTRODUCTION

CONTRIBUTIONS to cyprinid skull morphology in the decades following publication of Sagemehl's classic monograph (1891) were summed up by Gregory (1933). Although the family Cyprinidae is "probably the largest of the recognized fish families" (Hubbs and Lagler, 1947), these were few. Sagemehl, besides, gave more than proportionate attention to the skulls of Catostomidae, Homalopteridae and Cobitidae. The systematic groups within the family are still based on superficial characters, and its immediate antecedents remain obscure (Guenther, 1868; Sagemehl, 1891; Regan, 1911; Gregory, 1933; Nichols, 1938; Berg, 1940; Tretiakov, 1945, 1946; Kryzanovsky, 1947).

Teleostean skull morphology has since been enriched by important ontogenetic studies and by longer typological series, of both living and fossil provenience. The cyprinid skull in particular has begun to receive attention more commensurate with its importance. The subjects of the more important investigations are the ontogeny of the occipital region and Weberian ossicles (Nusbaum, 1908; Matveiev, 1929; de Beer, 1937: 140; Watson, 1939), and of the entire chondrocranium (Hubendick, 1942), the morphology of the ethmoid region (Starks, 1926), the pharyngeal process of the basioccipital (Chranilov, 1927), the pharyngeal teeth (Chu, 1935), the dermal bones related to the latero-sensory canals (Sagemehl, 1891; Allis, 1904; Tretiakov, 1945, 1946; Devillers, 1947; Lekander, 1949), and of the sensory canals themselves (Manigk, 1933; Devillers, 1944). Light is also shed on cyprinid skull morphology by the recent study of the homalopterid skull (Ramaswami, 1948). Published illustrations of cyprinid skulls, however, even in the osteologies of particular species (Koh, 1931; Tchang, 1950; Tchang and Pao, 1934), fail to show clearly all the bones, and an up-to-date nomenclature remains to be applied to all the skull bones of any one species.

An attempt has been made here (1) to describe the skull of a cyprinid, making full use of existing terminology with special application to the group; (2) to illustrate clearly each bone in relation to adjacent bones; and (3) to name each bone in conformity with the present state of teleostean skull morphology. Synonymies of the more controversial bones are considered in alphabetical order, under the names used in the description and figures. These names represent, in general, resolutions of the often conflicting claims of paleontology, of different branches of morphology, and of usage, past and present, here and abroad. No problem of naming has been consciously avoided, and the explicit citation of authorities, invoked in justification of the names decided upon, should facilitate constructive criticism.

MATERIAL AND METHODS

Twelve specimens of the bridled shiner, *Notropis bifrenatus* (Cope), including young of the year, yearlings and adults, were prepared as alizarin transparencies in the manner prescribed by Evans (1948), and dissected with minuten nadeln under a stereoscopic microscope. With the aid of a camera lucida, drawings were made at successive stages of dissection.

The skull represented here (Figs. 1–8) measured 10.5 mm. from the tip of the premaxillaries to the end of the pharyngeal process of the basioccipital. It was taken from a fish $2\frac{1}{16}$ inches in total length and 41.0 mm. in standard length (tip of snout to end of hypurals), known on the basis of previous studies (Harrington, 1947 *et seq.*) to be in its last year (third summer) of life. The selection of one of the smallest species, with abbreviated life span and early maturity, from this large and

representative genus, afforded an adult though somewhat neotenic skull in which the finer morphological features were not obscured by the thickening and over-growth of bone found in longer-lived species.

Description of the Osteocranium

Figs. 1–8

Olfactory Region

Cartilage bones: paired **lateral ethmoids** (LE) and **preethmoids** (PE), and median, unpaired **ethmoid** (E); dermal bones: median, apparently paired **supraethmoid** (SE), median, unpaired **prevomer** (PV), and **"rostral"** (RO), and paired **prefrontal** ossifications (PF).

The quadrant-shaped **ethmoid** (E, Figs. 1–3) lies in the sagittal plane with the vertical posterior edge perpendicular to the ventral edge and the curved anterodorsal edge conforming to the arc, and is more laterally compressed dorsad. Ventrally, it flares anterolaterally on either side of its median notch, which conforms with the anterior notch of the prevomer below (PV, Fig. 6). It ossifies as perichondral lamellae ensheathing the nasal septum anterodorsally and laterally. These lamellae are interconnected by cancellous endochondral ossification, which thus contributes to the ventral and posterior edges of the bone. Alizarin stains the endochondral bone more deeply than the lamellar bone here as elsewhere in the skull, perhaps indicating the persistence of some calcified cartilage. The ventral edge of the ethmoid rests upon, and is confluent with the thin horizontal plate of cartilage (planum ethmoidale) overlying the prevomer. Unossified residua of the sphenoseptal commissures converge on the dorsoposterior edge of the ethmoid connecting it on either side above the olfactory foramina with the lateral ethmoids (upper LE, Fig. 5). Each foramen olfactorium is thus bordered anteriorly by the posterior edge of the ethmoid, dorsally and posteriorly by the ectosteal extension of the sphenoseptal portion of the lateral ethmoid, and ventrally by the extension of its base rostrad.

Overlying and fused to the anterodorsal edge of the ethmoid, the butterfly-shaped **supraethmoid** (SE, Figs. 1, 4) extends thin, wing-like lamellae laterad in the horizontal plane. The tails of these lamellae over-reach the hind end of the ethmoid, and diverge on either side of the mesially narrowing anterior extremities of the frontals, which lie in the same plane. Although both halves of the supraethmoid are firmly fused with the ethmoid, the bone appears to be paired. According to de Beer (1937) this element seems to be paired in *Ameiurus* (p. 140), as it is in *Lepisosteus* (p. 144); and in *Amia* it arises from four groups of osteoblasts (Pehrson, 1922: 41; 1940: 9, "ethmoid or 'rostral' "). Pehrson considered it a derivative of the rostral mosaic of more primitive forms. Gregory (1933: 93) traced it back to one of the median rostrals. Among cyprinoids and characins, Sagemehl (1891: 497, 499) found all gradations between the condition in which the supraethmoid predominates with little invasion of the nasal septum by bone and that in which merely a bony nasal septum exists.

The complex **lateral ethmoids** (LE, Figs. 2, 3, 5, 6) consist of endochondral and perichondral bone and of intramembranous bony extensions, and are fused with the prefrontals laterally. Without reference to the chondrocranium (cf. figures of Hubendick), they are not easily comprehended. Each bone has a massive basal region (lower LE, Fig. 5) consisting essentially of perichondral bone capping laterally the incompletely ossified cartilage of the parethmoid cornu of Swinnerton (1902: 514). From this base, a thickened column of endochondral bone ensheathed in perichondral bone ascends dorsoposteriorly to the upper hind edge of the lateral ethmoid. This (upper LE, Fig. 5) represents the ossified anterior extremity of the taenia marginalis anterior. A similar ectosteally encased column of endochondral bone extends in the horizontal plane posterolaterally from the upper hind corner of the ethmoid to become broadly confluent with the first-mentioned column. This represents the ossified sphenoseptal commissure (taenia marginalis ethmoidalis). The ectosteal coverings of these two conformations are continuous with the lamellar portions of the rest of the bone. The column ascending from the base of the bone sends a horizontal intramembranous bony extension to meet in the mid-line its fellow from the other lateral ethmoid (middle LE, Fig. 5; cf. also Hubendick, 1942: 19, 22). The resulting platform is the foremost part of the cranial cavity floor. It narrows anteriorly

between the converging sphenoseptal portions of the lateral ethmoids, and is continued behind in the same plane by the upper, diverging plates of the orbitosphenoid. Viewed anterolaterally, the sphenoseptal region of the lateral ethmoid appears as a vertical plate with ventral incurved edge arching over the olfactory foramen, the endochondral core having been augmented in the vertical plane by the ventral extension of the ensheathing perichondral lamellae. An orbito-nasal foramen passes dorsolaterally from the orbit to open into the nasal cavity slightly laterad of the olfactory foramen. It is visible only in anterior or posterior view. From above, the sphenoseptal portions of the lateral ethmoids are seen (Fig. 5) to converge toward the posterior end of the locus of the ethmoid. This region is overlain by the anterior ends of the frontals. The slightly ossified cartilage of the parethmoid cornua, encased in the cap-like ectosteal bases of the lateral ethmoids, is continuous with the unossified cartilage (planum ethmoidale) between ethmoid and prevomer, which also extends over the anterior end of the parasphenoid. The posterior ends of the autopalatines (depressed in the figures) normally rest against the transverse ventral surfaces of the lateral ethmoids (cf. esp. Figs. 3, 6).

The **prefrontals** (PF, Figs. 2, 3, 5, 6) have the same appearance as other membrane bones, and are clearly not ossifications in the lamina orbitonasalis. Each is fused to the lateral border and ascending column (ossified taenia marginalis anterior) of the adjacent lateral ethmoid. Contiguous behind with the supraorbitals, they form the anterior boundaries of the orbits, and are included by Gregory (1933: 88) in the circumorbital series.

The **prevomer** (PV, Figs. 3, 5, 6), viewed in its entirety only from below, is a horizontal, thin, flat, paddle-shaped bone underlying the ethmoid, and slightly overlapping the anterior end of the parasphenoid ventrally. On each side of its medial, anterior notch, an oval extension protrudes anterolaterally beyond the forward limit of the ethmoid. Each extension is shaped like the bowl of a spoon and in each rests an egg-shaped preethmoid.

The **preethmoids,** composed of fragile, cancellous, endochondral bone, are firmly fused to their spoon-like receptacles. Their position is evident from below (Fig. 6) but their substance can be seen only from the sides or from above (PE, Figs. 3–5). They appear to be ossifications of the preethmoid cornua of Swinnerton (1902: 529), and serve for the attachment of the autopalatines. The fused preethmoids and prevomer are encased dorsally, anteriorly and laterally by cartilage continuous with that of the planum ethmoidale, already mentioned. The preethmoids are supported exclusively by the prevomer, and show no signs of semidivision, as in some cyprinids described by Starks (1926: 173). The "prenasals" of Koh (1931: 64) are probably the lateral elements of divided preethmoids. The autopalatines fit over the cartilage which covers the preethmoids laterally. A biconcave disc fits between the condyle of each maxillary bone and the cartilage covering the anterolateral surface of the adjacent preethmoid. This disc, also of cartilage, is unossified in *N. bifrenatus*. It is regarded by Starks (1926: 174) as the cyprinid equivalent of the catostomid submaxillary bone. The possibility that the preethmoid is an epiphysis of the submaxillary bone has been considered by Gregory (1933: 93), but in *N. bifrenatus* the preethmoid appears to be an ossification of the preethmoid cornu, and is distinct from the disc-like submaxillary element.

The shape of the **"rostral"** (our **kinethmoid,** see below) is apparent from the figures (RO, Figs. 3–6). Its relation to the sigmoid ligament between premaxillaries and ethmoid, its function in the protraction of the upper jaw, and other attributes have been thoroughly described (Sagemehl, 1891: 583; Gregory, 1933: 189; Eaton, 1935: 167; Hubendick, 1942: 16).

The **nasals** (N, Figs. 1, 4) are little more than tube bones, usually with slight basal flanges. Traversed by the nasal section of the supraorbital lateral line canals, they float in the cutis just lateral to the wings of the supraethmoid.

Orbital Region

Cartilage bones: unpaired, median **orbitosphenoid** (OSP), paired, lateral **pterosphenoids** (PTS); dermal bones (all paired): anterior and posterior **sclerotic** bones (S), **lachrymal** (LA), **suborbitals** 2–4 (unlabelled), **suborbital** 5 (SO_5), **dermosphenotic** or suborbital 6 (DSPH), **supraorbital** (SPO), **frontal** (F).

The upper, diverging plates of the **orbitosphenoid** (OSP, Figs. 2, 3, 5, 6), forming the floor and side walls of the cranial cavity, join the lateral ethmoids in front and the pterosphenoids behind, in broad sutures accentuated by intervening cartilage. Each upper plate of the orbitosphenoid slips anterodorsally into a mesial and a lateral lamella (Fig. 5). The cartilage found between these lamellae is a vestige of the taenia marginalis anterior. At the junction of these two upper plates with the ossified interorbital septum, there is no trace of a core of cartilage such as that found in *Leuciscus* by Hubendick (1942: 17, 20), although the three plates concerned agree otherwise with those of *Leuciscus* in being intramembranous ossifications. The upper two plates behind, at their confluence with the interorbital septum, extend posteriorly on either side of the sagittal plane; in this way they make a broad notch, which forms the anterior and anterolateral boundaries of the orbital foramen.

The **pterosphenoids** (PTS, Figs. 2, 3, 5, 6) are flat, irregularly hexagonal plates, their two more or less parallel vertical edges being the longest. Each pterosphenoid forms a suture with the orbitosphenoid anteriorly, with the prootic posteriorly, and with the autosphenotic dorsoposteriorly. Subdorsally, the suture between pterosphenoid and prootic is interrupted by the foramen for the trigeminal nerve (V, Figs. 3, 5, 6). The pterosphenoids are overlain by the frontals above; below, their free edges extend the lateral boundaries of the orbital foramen (OF, Figs. 5, 6) posteriorly. Each pterosphenoid ossifies as perichondral lamellae anteriorly, dorsally, and dorsoposteriorly, in connection with the taenia marginalis posterior, which Hubendick (1942: 21) found expanded here in *Leuciscus*. From the center of the bone to its ventral edge and to its posterior edge below the notch for the trigeminal nerve, each bone consists of a single lamella, but in the regions just referred to it is composed essentially of two lamellae enclosing a modicum of endochondral bone. Anterodorsally, the inner lamella is molded around the base of the cartilaginous epiphyseal bar where the latter stems from the remains of the taenia marginalis. The morphology of the epiphyseal bar (CEB, Fig. 5) has been considered by Pollard (1895: 414), Swinnerton (1902: 514), Kindred (1919: 10), Sagemehl (1891: 511), and Norman (1926: 435), and is by no means confined to cyprinoids as supposed by Sagemehl. In Figure 5, the boundaries of the anterior and posterior fontanelles of the chondrocranium, separated by the transverse, epiphyseal bar, are emphasized by heavy lines; the course of the epiphyseal bar is indicated by broken lines. Of the two most conspicuous foramina in the pterosphenoid, the anterodorsal one, partly hidden under the root of the epiphyseal bar, accommodates the ophthalmic branch of the facial nerve, and the more posterior, ventral one, the ophthalmic branch of the trigeminal (Kindred, 1919: 75; Hubendick, 1942: 21).

Of the two **sclerotic** bones (S, Fig. 1) of each orbit, that capping the eyeball anteriorly is shaped like a watch glass, whereas the posterior one is of more irregular contour.

With the exception of the dermosphenotic, each bone of the **suborbital** series (Figs. 1, 4) is a flat plate surmounted by a bony tube perforated by irregularly oval holes related to the pores of the suborbital lateral-line canal. Suborbitals 4 and 5 are often fused and may or may not show evidence of this by a horizontal line of fusion. These two elements may be separate on one side of a fish and fused on the other. The **dermosphenotic** (DSPH) is reduced to a bony tube, which is often lacking. When present, it floats in the cutis over the autosphenotic. At its upper margin, the fifth suborbital (SO_5) is contiguous at right angles with the postorbital process of the autosphenotic (SO_5, DO, Fig. 4; SO_5, SPH, Fig. 1).

Each **supraorbital** bone (SPO, Figs. 1, 4) forms the margin of the orbit anterodorsally between those portions of the margin formed by prefrontal and frontal. It resembles an eyelid, and articulates anteromedially with the prefrontal and posteromedially with the frontal.

The **frontals** (F, Figs. 1, 4) roof the brain cavity and are exceeded in size only by the opercular. They cover the upper edges of the lateral ethmoids, orbitosphenoid, pterosphenoids, and autosphenoids, and overlap the anterior edges of the parietals. They are irregularly juxtaposed in the midline, the left bone overlapping the right anteriorly, and the right, the left posteriorly near the parietals. A broad, shallow, transverse furrow crosses the two bones. This reflects the course of the underly-

ing, cartilaginous epiphyseal bar, which restricts the dorsal expansion of the brain here between the anterior and posterior fontanelles. Each frontal is notched at its posterolateral corner so as to expose the lateral temporal fossa (DO, Fig. 4), which is confined mostly to the dorsal aspect of the postorbital process of the autosphenotic. Anteriorly, each frontal narrows gradually to the incurve bordering the mesial edge of the supraorbital bone, then abruptly, to a point, in conformity with the sphenoseptal regions of the underlying lateral ethmoids. A supraorbital region extends laterad from the bony supraorbital canal tube of each frontal, and forms the lateral margin and roof of the orbit. The region of the frontal medial to the canal tube roofs the cranial cavity. The tubular and plate-like components of the frontal are inseparably fused.

The canal tube does not reach the posterior margin of the frontal, and has no medial collateral branch as in some cyprinids (cf. Sagemehl, 1891: 508; Allis, 1904, fig. 17; Tretiakov, 1945), nor does it or its enclosed canal connect with the suborbital-postorbital canal. Sagemehl (1891: 508) noted a wide separation between the posterior angle of the frontal and the supratemporal ("squamosal") of cyprinids, which was disputed by Allis (1904: 437 and fig. 17), who found this untrue of *Carassius*. In the cyprinids examined by Lekander (1949: 123), the supraorbital canal did not join the suborbital, only the latter continuing as the postorbital canal. These apparent contradictions are resolved, however, by the observation of Tretiakov (1945) that the supra-, sub- and postorbital canals are conjoined in *Cyprinus*, *Carassius*, *Squalius*, and a few other genera, but that in a considerable number of cyprinid genera, the supraorbital canal does not join the suborbital canal.

On the ventral side of each frontal, opposite the course of the canal tube, a ridge-like lamella of bone extends toward the upper plate of the

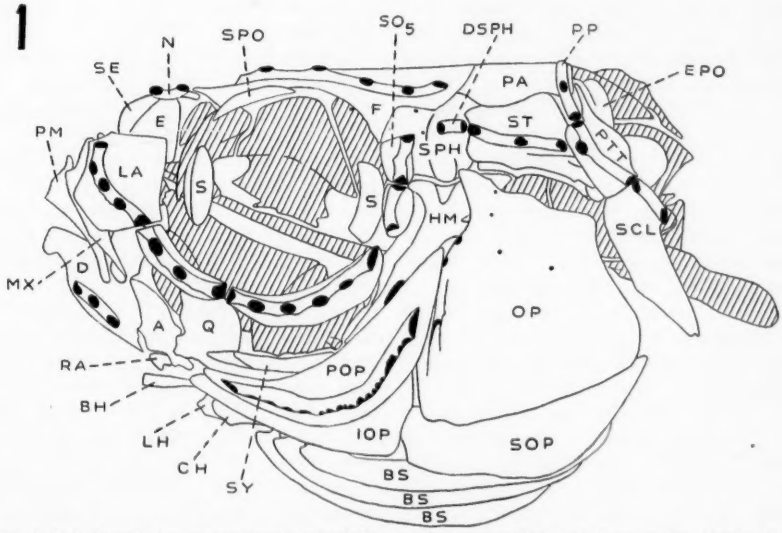

Fig. 1. Left lateral view of the intact skull of *Notropis bifrenatus*. Hind end of premaxilla disjointed and depressed.

A, angular ("articular," dermarticular); BH, basihyal; BS, branchiostegals; CH, ceratohyal; D, dentary (dental-splenial); DSPH, interpreted here as a vestigial dermosphenotic (SO_6), but perhaps instead an intertemporal; E, ethmoid; EPO, epiotic; F, frontal; HM, hyomandibular; IOP, interopercular; LA, lachrymal (lacrymal, lacrimal, preorbital, SO_1); LH, lower hypohyal; MX, maxillary; N, nasal; OP, opercular; PA, parietal; POP, preopercular; PM, premaxillary; PP, medial extrascapular ("post-parietal"); PTT, posttemporal with fused lateral extrascapular; Q, quadrate; RA, retroarticular ("angular"); S, sclerotic bones; SCL, supracleithrum; SE, supraethmoid (dermethmoid); SO_5, suborbital (infraorbital) 5; SOP, subopercular; SPH, autosphenotic; SPO, supraorbital; ST, supratemporal-intertemporal (supratemporal-intertemporal-membranopterotic); SY, symplectic; UNLABELLED: suborbitals 2–4.

orbitosphenoid, thus contributing to the side wall of the cranial cavity.

Otic Region

Cartilage bones: paired **autosphenotics** (SPH), **autopterotics** (PTO), **prootics** (PRO), **epiotics** (EPO), **opisthotics** (OPIS), **exoccipitals** (EO), unpaired **supraoccipital** (SOC); dermal bones: paired **supratemporals** (ST), **parietals** (PA), **medial extrascapulars** (PP), **posttemporals** and fused **lateral extrascapulars** (PTT), **supracleithra** (SCL), unpaired **dermosupraoccipital** (DSOC).

The sutures between the cartilage bones of the otic region are widely separated by intervening cartilage. The bones themselves, in thickness, quality of staining, and conformation, reflect their derivation from cartilage.

The **autosphenotic** (SPH, Figs. 1–6) forms a suture with the pterosphenoid anteriorly, with the prootic ventrally, and with the autopterotic posteriorly. Its upper edge contributes to the lateral margin of the posterior chondrocranial fontanelle. This margin (heavy line, Fig. 5) is continued caudad by the mesial edge of a rhomboidal plate of cartilage (a remnant of the tectum synoticum), extending between the opposing upper edges of autosphenotic, autopterotic, epiotic and supraoccipital (dotted, Figs. 2, 3, 5, 7). The autosphenotic is drawn out anterolaterally in a prominent postorbital process (SPH, Figs. 4–6), against which the upper mesial surface of the fifth suborbital rests, and the upper surface of which constitutes the lateral temporal fossa (DO, Fig. 4). The dorsal border of the autosphenotic is overlain anteriorly by the frontal and posteriorly by the parietal. Its posterior border is overlain laterally by the forward extension of the supratemporal. The middle third of the bone is traversed vertically by a broad, rounded ridge molded over the anterior semicircular canal (AC, Fig. 3), which it encloses. A small mid-portion of this canal is excluded from the cranial cavity by the conjunction on its mesial surface of two bone lamellae, which arise from the mesial surface of the autosphenotic on either side of the canal. The lower edge of the autosphenotic contributes to the facet for the hyomandibular. The internal surface of the autosphenotic forms the anterolateral boundary of the cranial cavity.

The **autopterotic** (PTO, Figs. 3, 5–7) forms a suture with the autosphenotic anteriorly, with the epiotic and exoccipital posteriorly, and with the prootic anteroventrally. The apex of its dorsal edge borders on the cartilage plate already mentioned. Its upper portion contributes to the surface of the skull externally and to the vault of the subtemporal fossa (STF, Fig. 6) internally, within which it forms a suture with a lamella of the epiotic. Ventrolaterally, it rolls around the horizontal semicircular canal (HC, Fig. 3), rejoining its upper portion within the fossa, thus completely enclosing the canal, and forming the outer margin of the fossa. In the intact skull, the entire dorsolateral surface of the autopterotic is covered over by the lamellar (membranopterotic) portion of the supratemporal bone (ST, Figs. 1, 2, 4, 7), with which it is fused, so that merely the inrolled lower margin and hindmost part of the autopterotic are visible.

The **epiotic** (EPO, Figs. 1–5, 7) encloses the posterior semicircular canal, which determines the broad ridge (PC, Fig. 3) at the upper posterolateral angle of the skull. In its passage through the bone, the canal is covered by a bone lamella mesially as well as superficially. The epiotic forms a suture with the supraoccipital dorsomesially, with the autopterotic ventroanteriorly, and with the exoccipital ventroposteriorly and also ventromesially within the subtemporal fossa. Inside the fossa, the anteromedial edge of the internal lamella of this bone, which forms the lateral and hind curvature of the fossa roof, is opposed to the posterolateral border of the prootic, with which it is connected through the intervention of cartilage. This cartilage (dotted, Fig. 6) completes the fossa roof between these two bones and the autopterotic. Sagemehl (1891: 554) noted similar relationships within the subtemporal fossa. On the dorsolateral surface of the epiotic, just in front of the ridge of the semicircular canal, an apolamella of bone serving for the articulation of the posttemporal profects lateroventrally (Figs. 2, 3, 5, 7). A small joramen opens just posterior to the base of this projection.

The **prootic** (PRO, Figs. 2, 3, 5, 6) forms a suture with the pterosphenoid anteriorly except for the interruption of the trigeminal notch (V, Figs. 3, 5, 6), with the autosphenotic

and the autopterotic dorsolaterally, with the exoccipital lateroposteriorly, and with the basioccipital posteriorly. Its posterolateral extension forms the anteromedial curvature of the subtemporal fossa roof, and is connected here, between its sutures with autopterotic and exoccipital, with the opposing anteromedial edge of the inner lamella of the epiotic through the intervention of the cartilage just mentioned. On the mesial surface of the prootic, at its anterior edge, is found the trigemino-facialis recess. This recess (between V and VII, Fig. 5) is bounded laterally by a bony ridge (between V and VII, Figs. 3, 6), separating the trigeminal notch from the facial foramen, and apparently ossified in relation to the lateral commissure. On the external, ventrolateral aspect of the prootic, a prominent bulla acustica utricularis (BAU, Figs. 2, 3, 6) encloses the utriculus with its contained lapillus (a, b, Fig. 8). The recessus utricularis, on the inner surface of the bone opposite the bulla, is separated from the rest of the inner surface by a ridge running diagonally from just behind the facial foramen toward the posteromedial angle of the bone. Ventromesially, the prootics slip into two lamellae running the length of these bones. The more extensive, dorsal lamellae meet in the midline to form the prootic bridge over the posterior eye-muscle canal (myodome), which is also the floor of the brain cavity. These dorsal lamellae diverge anteriorly, leaving a gap between them, the hypophyseal foramen (HF, Fig. 5), through which the stalk of the hypophysis passes. The opposing ventral lamellae are shorter, and leave a much longer gap between them, which is closed off ventrally by the parasphenoid. The parasphenoid forms

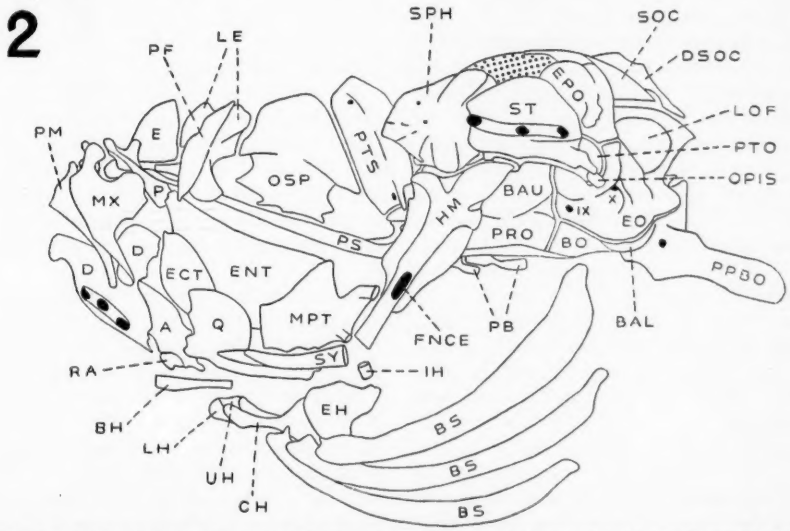

Fig. 2. Left lateral view of the skull of *N. bifrenatus*, after removal of supraethmoid, nasals, supraorbitals, frontals, parietals, extrascapulars, posttemporals, supracleithra, sclerotics, urohyal, suborbital series, the right half of the branchiocranium, and the left half of the branchial region except for the pharyngobranchials. Branchiostegals displaced to disclose their contours.

A, angular ("articular," dermarticular); BAL, bulla acustica lagenaris; BAU, bulla acustica utricularis; BH, basihyal; BO, basioccipital; BS, branchiostegals; CH, ceratohyal; D, dentary (dental-splenial); DSOC, intramembranous spine of supraoccipital (= dermosupraoccipital?); E, ethmoid; ECT, ectopterygoid; EH, epihyal; ENT, endopterygoid (entopterygoid, mesopterygoid, pterygoid); EO, exoccipital (lateral occipital); EPO, epiotic; FNCE, exit of facial nerve canal of hyomandibular bone; HM, hyomandibular; IH, interhyal (stylohyal); LE, lateral ethmoid; LH, lower hypohyal; LOF, lateral occipital foramen; MPT, metapterygoid; MX, maxillary; OPIS, opisthotic (intercalary); OSP, orbitosphenoid; P, autopalatine; PB, pharyngobranchials 1 and 2; PF, prefrontal ossification; PM, premaxillary; PPBO, pharyngeal process of the basioccipital; PRO, prootic; PS, parasphenoid (homologue of mammalian vomer); PTO, autopterotic; PTS, pterosphenoid (pleurosphenoid); Q, quadrate; RA, retroarticular ("angular"); SOC, supraoccipital; SPH, autosphenotic; ST, supratemporal-intertemporal (supratemporal-intertemporal-membranopterotic); SY, symplectic; UH, upper hypohyal; IX, foramen for glossopharyngeal nerve; X, foramen for vagus nerve.

the floor, and the dorsal and ventral lamellae of the prootics form respectively the roof and side walls of the myodome, which is open in front. Behind the prootic, the roof and side walls of the myodome are continued by the ventral surface of the basioccipital pushed in from the ventral side to form the blind end of the myodome, which is enclosed ventrally here by the posterior end of the parasphenoid. The hind end of each prootic is thickened where it adjoins the basioccipital lateral to the myodome. A conical excavation within this thickening of the prootic opens posteriorly to receive the anterior end of the sagitta (sacculith), the remainder of which lies in the saccular recess of the basioccipital.

The **exoccipital** (EO, Figs. 2–7) forms a suture with the autopterotic anterolaterally, with the epiotic dorsally outside, and laterally inside the subtemporal fossa, with the prootic anteriorly both outside and inside the fossa. The exoccipital forms a suture mesially with the basioccipital, except at its hindmost end where the two bones interdigitate so closely as to appear fused (Figs. 2, 3). This is the only boundary between cartilage bones lacking intervening cartilage, and is restricted to the lateral surface of the proatlas vertebral centrum of the basioccipital. The posterodorsal extremity of the exoccipital is reduced to a strip of bone forming the margin of the enormous lateral occipital foramen (LOF, Figs. 2–5, 7). Dorsally, this bony strip forms a short suture with the supraoccipital (Figs. 2–5, 7), and mesially it is connected with its fellow of the opposite side by a median dorsal plate of cartilage (not shown in the figures), which forms the roof of the foramen magnum. Within the cranial cavity, each exoccipital sends a horizontal plate to meet a corresponding plate from the other exoccipital in the midline. These plates form a platform (between FM and CSI, Fig. 7) which is the floor of the foramen magnum and the roof of the cavum sinus imparis. The basioccipital is thus excluded from the foramen magnum. A vertical ridge of bone descends from the under surface of each of these plates to form a small part of the lateral walls of the cavum sinus imparis; the remainder is formed by vertical plates ascending from the floor of the basioccipital to meet them. The glossopharyngeal foramen (IX, Figs. 2, 3, 6) opens on the lateral surface of the exoccipital at its anteroventral corner. Behind this opening, below the bulge induced by the conjunction of horizontal and posterior semicircular canals, and just in front of the oblique ridge between the lateral and the posterior surfaces of the bone, is the foramen for the vagus (X, Figs. 2, 3, 6). The full size of this large foramen is apparent only in ventral view (X, Fig. 6).

The **supraoccipital** (SOC, Figs. 2–5, 7) is shield-shaped. Its concave, anterior border conforms to the posteromedial margin of the posterior chondrocranial fontanelle. The small median convexity within this anterior border suggests the influence of an abortive taenia tecti medianalis. The supraoccipital forms sutures laterally with the epiotics and exoccipitals. On either side, anterior to these sutures, it adjoins the cartilage plate first mentioned in connection with the autosphenotics; posterior to the sutures, it adjoins the cartilage roofing the foramen magnum.

The occipital spine (DSOC, Figs. 2, 3, 7; unlabelled, Figs. 4, 5) may possibly represent the **dermosupraoccipital.** It is composed of two thin plates overlying and fused to the posterolateral surfaces of the supraoccipital. The plates converge in the sagittal plane to form the spine, which projects beyond the hind edge of the supraoccipital.

The **opisthotic** (intercalary) is a tiny limpet-shaped ossicle (OPIS, Figs. 2–4, 6, 7) overlying the opposing edges of autopterotic and exoccipital on the posteroventral aspect of the rounded margin of the subtemporal fossa. It lies across the suture in a slight depression shared by both bones. It is a typical cyprinid opisthotic (Sagemehl, 1891: 556) in neither contributing to the wall of the auditory capsule nor retaining any connection with the posttemporal.

Of the dermal bones of the otic region, the **supratemporal** (ST, Figs. 1, 2, 4, 7) has been mentioned already. It not only covers over the autopterotic (PTO, Figs. 3, 5–7) but overlaps the hind edge of the autosphenotic hiding the suture between these two bones, and overlaps also the anterior edge of the epiotic hiding much of the autopterotic-epiotic suture (Fig. 3). It is bordered dorsoposteriorly by the lateral portion of the medial extrascapular. Its

posteroventral corner is drawn out into a process for the articulation of the posttemporal bone (cf. ST, PTT, Figs. 1, 2). It is traversed by the postorbital lateral line canal, which it encloses in a bony tubule. A slit-like opening under the posterior edge of the supratemporal just above its posttemporal process leads into a slight, blind cavity between the supratemporal and the surfaces of the autopterotic and epiotic adjoining their common suture. This is a vestigial representative of the Temporalhöhle of Sagemehl (1891: 553), termed the posterior temporal fossa or supratemporal fossa by Regan (1911: 26–28), who used the latter names interchangeably with the respect to the Cypriniformes. According to Regan's specifications, the posttemporal bone of *N. bifrenatus* would be regarded as a posterior extension of the roof of this fossa. The fossa is best seen in posterior view, just lateroventral to the posttemporal spur (apolamella) of the epiotic and under the hind edge of the supratemporal bone (unlabelled, Fig. 7).

The **parietals** (PA, Figs. 1, 4) overlie the hind part of the posterior chondrocranial fontanelle, the upper portions of the autosphenotics, supratemporals, epiotics, and supraoccipital, as well as the entire surface of the cartilaginous remnant of the tectum synoticum (dotted, Figs. 2, 3, 5, 7). The right parietal overlaps the left in the midline, and both are overlapped anteriorly by the frontals. They

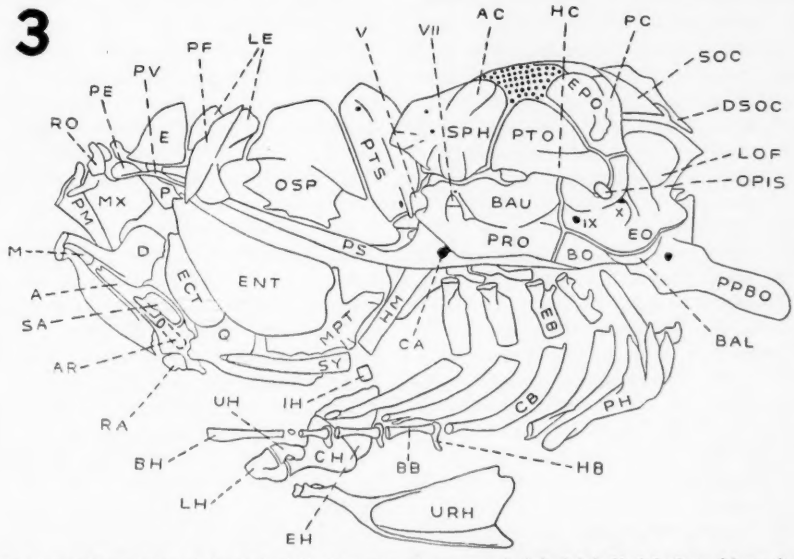

Fig. 3. Left lateral view of the skull of *N. bifrenatus*, after removal of the left half of the branchiocranium. Neurocranium as in Fig. 2, except for the removal of the supratemporal-intertemporal. The position of the articular (endochondral ossification) is indicated by broken lines.

A, angular ("articular," dermarticular); AC, anterior semicircular canal; AR, articular (endochondral ossification); BAL, bulla acustica lagenaris; BAU, bulla acustica utricularis; BB, third basibranchial; BH, basihyal; BO, basioccipital; CA, foramen for carotid artery; CB, third ceratobranchial; CH, ceratohyal; D, dentary (dental-splenial); DSOC, intramembranous spine of supraoccipital (= dermosupraoccipital?); E, ethmoid; EB, third epibranchial; ECT, ectopterygoid; EH, epihyal; ENT, endopterygoid (entopterygoid, mesopterygoid, pterygoid); EO, exoccipital (lateral occipital); EPO, epiotic; HB, third hypobranchial; HC, horizontal semicircular canal; HM, hyomandibular; IH, interhyal (stylohyal); LE, lateral ethmoid; LH, lower hypohyal; LOF, lateral occipital foramen; M, mentomeckelian (mentomandibular) ossification; MPT, metapterygoid; MX, maxillary; OPIS, opisthotic (intercalary); OSP, orbitosphenoid; P, autopalatine; PC, posterior semicircular canal; PE, preethmoid; PF, prefrontal ossification; PH, pharyngeal bone (fifth ceratobranchial); PM, premaxillary; PPBO, pharyngeal process of the basioccipital; PRO, prootic; PS, parasphenoid (homologue of mammalian vomer); PTO, autopterotic; PTS, pterosphenoid (pleurosphenoid); PV, prevomer; Q, quadrate; RA, retroarticular ("angular"); RO, "rostral" (kinethmoid, *nomen nova*); SA, coronomeckelian (sesamoid articular, sesamoid angular); SOC, supraoccipital; SPH, autosphenotic; SY, symplectic; UH, upper hypohyal; URH, urohyal (parahyoid); V, foramen for trigeminal nerve; VII, foramen for facial nerve; IX, foramen for glossopharyngeal nerve; X, foramen for vagus nerve; UNLABELLED: epibranchials and ceratobranchials 1, 2, and 4; pharyngobranchials, basibranchials and hypobranchials 1 and 2; NOT FIGURED: the ossified gill-rakers.

are smooth, slightly convex dorsally, and almost square.

A tubular bone, the **medial extrascapular** (PP, Figs. 1, 4), enclosing the transverse commissural or supratemporal lateral-line canal, runs along the upper surface of each parietal near its posterior margin. Its medial two-thirds is fused to the lateral two-thirds of the parietal; its lateral third is free, and extends along the posterior edge of the supratemporal bone above the dorsoanterior surface of the epiotic. The medial extrascapular transmits its enclosed laterosensory canal to a bony tubule fused to the posttemporal bone.

The lancet-shaped upper end of the **posttemporal** (PTT, Fig. 1) overlies the epiotic just in front of the ridge of the semicircular canal. It broadens out below into a wide, flat plate, which rests on the posttemporal process of the supratemporal bone and upon the posttemporal process (apolamella) arising from the surface of the epiotic. The bony tubule fused to the posttemporal is the lateral extrascapular.

The **lateral extrascapular** in its upper part resembles that of *Abramis*, as described by Tretiakov (1945), in having a long vertical and a short horizontal limb. In enclosing the conjunction of postorbital, supratemporal and posttemporal canals, it fulfils Tretiakov's criterion for the lateral extrascapular. This interpretation of the tube bone fused to the posttemporal as the lateral extrascapular is not inconsistent with descriptions of this element by Sagemehl (1891: 507), Allis (1904, fig. 17), Gregory (1933: 89 and fig. 74, "scale bone"), and Koh (1931: 77 and Plate VI, figs. 1–2, "supratemporal").

The **supracleithrum** (SCL, Fig. 1) is a rather flat, paddle-shaped bone with a thickened handle-like upper end articulating with the under surface of the posttemporal, and a broader and longer lower part articulating with the lateral surface of the cleithrum below. For a short distance along the middle of its posterior edge a bony tube surmounts its lateral surface. The tube is fused to the supracleithrum, and transmits the posttemporal canal from the posttemporal bone to the lateral-line scales.

Basicranial Region

Cartilage bone: unpaired **basioccipital** (BO); dermal bone: unpaired **parasphenoid** (PS). Otoliths: paired **lapillus, asteriscus, sagitta** (Fig. 8).

The **basioccipital** (BO, PPBO, MPBO, or CPRA, Figs. 2–7) has been mentioned above in connection with the prootics, exoccipitals, and the sagittae. It forms the roof and posterior wall of the hind end of the myodome, the floor and side walls of the cavum sinus imparis, and of each recessus sacculi. Its ventral wall is continuous behind with the conical, posteriorly concave centrum of the subsumed proatlas vertebra. Below and behind this it is produced in an oblique, posteroventrally directed pharyngeal process, serving as origin for those muscles concerned with the retraction of the toothed fifth ceratobranchials (pharyngeal bones). Its anterior edge, which forms a suture with the posterior medial edges of the prootics, is W-shaped, the medial arch forming a continuation of the myodome roof, and each lateral inverted arch being the floor of a recessus sacculi. Dorsolaterally, on each side, the basioccipital forms a suture with the ventromedial edge of the adjacent exoccipital. Towards its posterior end, this suture yields to an interdigitation of the two bones so intimate as to simulate fusion, as mentioned above. This interdigitation occurs between the posteriorly produced hind end of the exoccipital and the lateral surface of the centrum of the proatlas vertebra of the basioccipital. From the dorsal surface of the basioccipital floor, where it arches over the myodome, two thin plates ascend to meet opposing ventral ridges under the horizontal plates of the exoccipitals above. These plates of the basioccipital form not only the lateral walls of the cavum sinus imparis, as already mentioned, but each also forms the medial wall of the adjacent recessus sacculi. The position of the recessus sacculi is reflected externally by a ventrolateral bulge involving basioccipital and exoccipital and termed the bulla acustica lagenaris (BAL, Figs. 2, 3, 7) by Sagemehl (1891: 560). The bulla is the outer wall of the recess, which lodges the otoliths known as asteriscus and sagitta (c–f, Fig. 8). The pharyngeal process of the basioccipital is laterally compressed posteriorly into a vertical plate, but widens out anteriorly to form, below, a horizontal, ventrally concave, masticatory plate, which opposes the teeth of the pharyngeal bones (PH, Fig. 3). At the broad base of the pharyngeal process, just below the proatlas

vertebral centrum, the large canal for the aorta (AO, Figs. 4–7) opens dorsoposteriorly. From this opening, the canal continues anteroventrally to open on the ventral surface of the basioccipital.

The **parasphenoid** (PS, Figs. 2, 3, 5, 6), which is the longest bone in the skull, extends in the midline along the greater part of the ventral length of the neurocranium. At its anterior end, it overlaps and is closely applied to the upper surface of the hind end of the prevomer, and is overlain dorsally by the posterior end of the cartilaginous planum ethmoidale, which separates it from the ventromesial borders of the lateral ethmoids and from the hind end of the ventral edge of the ethmoid. From here to just in front of the otic region, it constitutes a thick, narrow strut of bone which skirts the lower edge of the vertical plate (ossified interorbital septum) of the orbitosphenoid. As it approaches the prootics, it widens abruptly to its maximum width, becoming at the same time gradually thinner dorsoventrally. It finally tapers to a point, under the ventral surface of the basioccipital, and is firmly attached to the ventral surfaces of both prootics and basioccipital to form the floor of the posterior myodome. It is notched opposite the facial foramen of each side, each notch forming with the adjacent surface of the prootic a carotid foramen (CA, Figs. 3, 6). In front of the carotid foramina, the parasphenoid forms the side walls of the myodome also, as the ventral lamellae of the prootics do not extend forward beyond these foramina. Just behind the level of the foramina, the pharyngobranchials (PB, Fig. 2) are attached loosely to its ventral surface. On the dorsal surface of the bone in the sagittal plane, a vertical ridge runs from below the hind end of the orbitosphenoid to about the level of the carotid foramina. Toward its posterior end, this ridge is produced into a vertical pillar. This flares out above into a small platform, the entire process resembling a tack (PS, Figs. 2, 3, 5). The ridge with its tack-like process partially divides the foremost portion of the posterior myodome into two corridors. The platform or

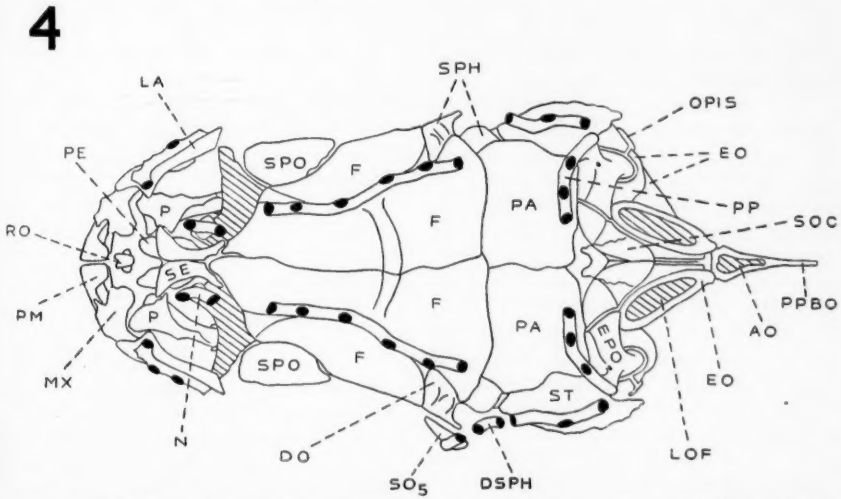

Fig. 4. Dorsal view of the skull of *N. bifrenatus* after removal of posttemporals, supracleithra, and most of the bones of the suborbital series. The prefrontals, lateral ethmoids, the lateral occipital foramina, and the aortic canal of the basioccipital are shaded.

AO, canal for the aorta in the basioccipital; DO, lateral temporal fossa (dilatator operculi muscle origin); DSPH, interpreted here as a vestigial dermosphenotic (SO_6), but perhaps instead, an intertemporal; EO, exoccipital (lateral occipital); EPO, epiotic; F, frontal; LA, lachrymal (lacrymal, lacrimal, preorbital, SO_1); LOF, lateral occipital foramen; MX, maxillary; N, nasal; OPIS, opisthotic (intercalary); P, autopalatine; PA, parietal; PE, preethmoid; PM, premaxillary; PP, medial extrascapular ("postparietal"); PPBO, pharyngeal process of the basioccipital; RO, "rostral" (kinethmoid, *nomen nova*); SE, supraethmoid (dermethmoid); SO_5, suborbital (infraorbital) 5; SOC, supraoccipital; SPH, autosphenotic; SPO, supraorbital; ST, supratemporal-intertemporal (supratemporal-intertemporal-membranopterotic).

head of the tack-shaped process is usually incompletely formed; it roofs part of the myodome so as to separate the optic foramen from the hypophyseal foramen (PS, Fig. 5). As Sagemehl (1891: 575) noted, the entire process is reminiscent of the teleostean basisphenoid, but, as he observed, it shows no evidence of being any more than a prong of the parasphenoid. He declared the basisphenoid to be lacking throughout the Ostariophysi, an opinion shared by Berg (1940: 442). On the other hand (see below under synonymy of basisphenoid), Holmgren and Stensiö (1936: 489) affirm its presence in cyprinids, and its presence in the Ameiuridae is affirmed by Vrolik (1873: 266), McMurrich (1884: 275), Kindred (1919: 73, "suprasphenoid"), and de Beer (1937: 140).

The otoliths, composed of crystalline calc spar (Moodie, 1922: 330), come into consideration in relation to the otic bones. These are drawn on a larger scale (Fig. 8, a–f) than the other figures but with the aid of a camera lucida so as to show their comparative sizes. Their orientation is explained in the legend to the figure. In general, they agree with other cyprinid otoliths described (Shepherd, 1910, 1914; Manning, 1923; Frost, 1925; Adams, 1940), but show a few notable differences, which alone will be considered here.

In *N. bifrenatus*, as in other cyprinids, the **lapillus** (utriculith) lies in the recessus utriculi of the prootic, opposite the bulla acustica utricularis (BAU, Figs. 2, 3, 6), whereas the **asteriscus** (lagenalith) and **sagitta** (sacculith) are both lodged in the recessus sacculi of the basioccipital, opposite the bulla acustica lagenaris (BAL, Figs. 2, 3, 7). The assertion (Shepherd, 1914: 132) that the cyprinid skull shows no external evidence of the location of the otoliths is contradicted by the existence of these bullae. The lapillus is slightly larger than the asteriscus. It lies flat, with its greatest dimension in the transverse plane and its least dimension in the vertical plane. The disc-shaped, asteriscus occupies the lateral portion of the recessus sacculi, where it stands on edge with convex surface lateral and plane surface medial, having the usual features of a cyprinid asteriscus. The long, slender and delicate sagitta lies mesial to the asteriscus in the same recess, its anterior end projecting from this recess in the basioccipital into the excavation in the posterior edge of the prootic. It lies in a parasagittal plane and almost horizontally, its anterior end slightly higher than its posterior end, having the usual plate-like expansion anteriorly and the needle-like extension posteriorly. Besides these features, there is a large spoon-shaped lamella applied to its anterior half, and opposite this, two tooth-like projections. The relationships of these three otoliths to the membranous labyrinth and its sensory maculae have been figured for *Carassius* by Manning (1923: 8, 9).

According to Frost (1925: 557), "... in Cyprinidae, the asteriscus is always the largest though in *Leuciscus cephalus* and *Tinca* the lapillus approaches it in size." However, he found the lapillus to be extremely variable, differing even among closely related species, and regards it of value in identification. Shepherd (1910: 57) found the asteriscus to be the largest otolith in Cyprinidae.. Adams (1940: 510) made the same assertion after examining four species belonging to the genera *Cyprinus*, *Carassius*, *Abramis* (*Notemigonus?*), and *Notropis!* Adams stated also that the lapillus is almost perpendicular, its long axis being dorsoventral and slightly inclined to the interior.

The relationships observed by the present writer in *N. bifrenatus* are not therefore in accord with those of the above writers with respect to the relative sizes of lapillus and asteriscus in cyprinids, nor with that of Adams with respect to the dimensions and orientation of the lapillus. Manning's figures also show the asteriscus to be larger than the lapillus, but the lapillus seems to be placed in *Carassius* as it is in *N. bifrenatus*.

Oromandibular Region

Cartilage bones: paired **autopalatines** (P), **etaptmerygoids** (MPT), **quadrates** (Q), **mentomeckelian** ossifications (M), **articular** ossifications (AR), **retroarticulars** (RA); dermal bones: paired **endopterygoids** (ENT), **ectopterygoids** (ECT), **premaxillaries** (PM), **maxillaries** (MX), **angulars** (A), **coronomeckelians** (SA), **dentaries** (D).

The posterior end of each **autopalatine** (P, Figs. 2–6) is rod-like and rests with its upper surface against the transverse ventral edge of the adjacent lateral ethmoid. It is movably articulated behind with the endopterygoid.

The anterior half of the bone is more complicated, having laterally a longitudinal ridge terminating anteriorly in a maxillary process, and mesially, a ventral and a dorsal wing which receive between them the cartilage-covered lateral surface of the preethmoid bone. This is the type of articulation termed disartete by Swinnerton (1902: 556), who also noted in other cyprinids that the mobility of the suspensory apparatus is ensured by the autopalatine-endopterygoid articulation (p. 583).

The **metapterygoids** (MPT, Figs. 2, 3) are broad, flat plates. Each bone shows traces of its cartilaginous origin in the retention of some calcification within its two, thick, bony struts. One strut extends in the dorsoposterior angle of the bone, forming the chief point of articulation with the hyomandibular, the other extends to the cartilage separating hyomandibular and symplectic, opposite the interhyal. The prominent angle in the mid-dorsal edge of the bone appears to have ossified in connection with the metapterygoid process discussed by Hubendick (1942: 15, 18). Dorsoanteriorly, the mesial surface of the metapterygoid is applied to the posterior lateral surface of the endopterygoid. The ventral edge of the metapterygoid borders on the dorsal edge of the symplectic.

Anteriorly, the **quadrate** (Q, Figs. 2, 3) is flat and fan-shaped; posteriorly, it is produced in a long, thick, handle-like strut. This strut is separated from the metapterygoid by the intervention of the long, slender symplectic. Dorsally, the mesial surface of the quadrate is applied to the lower lateral surface of the endopterygoid posteriorly, and to the lower lateral surface of the ectopterygoid anteriorly. At its anteroventral angle, it bears a condyle movably articulated with a notch in the angular.

The **ectopterygoid** (ECT, Figs. 2, 3) has somewhat the shape of a leaf with dorsally directed petiole, as has been noted in *Carassius* (Koh, 1931). Its mesial surface is applied above to the lateral surface of the anteroventral corner of the endopterygoid. Below, its lateral surface is applied to the mesial surface of the anterior part of the quadrate. Ectoptery-

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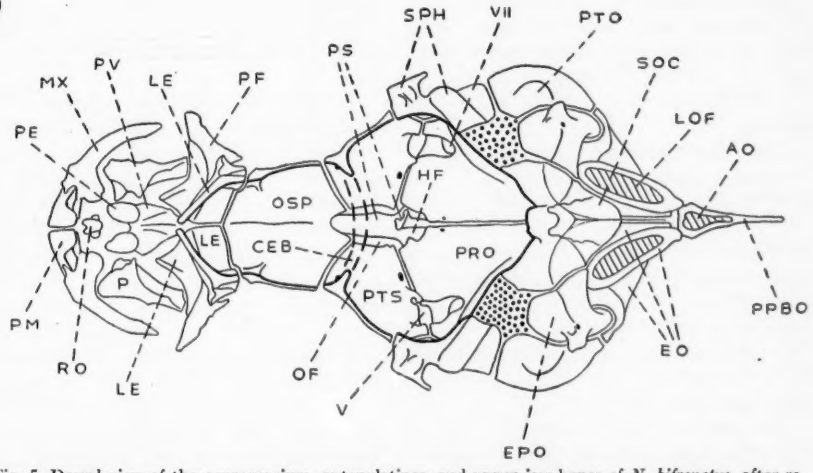

Fig. 5. Dorsal view of the neurocranium, autopalatines, and upper jaw bones of *N. bifrenatus*, after removal of superficial bones. The boundaries of the anterior and posterior chondrocranial fontanelles are emphasized by heavy lines. The locus of the epiphyseal bar is indicated by heavy broken lines.

AO, canal for aorta in basioccipital; CEB, locus of cartilaginous epiphyseal bar; EO, exoccipital (lateral occipital); EPO, epiotic; HF, hypophyseal foramen; LE, lateral ethmoid; LOF, lateral occipital foramen; MX, maxillary; OF, optic foramen; OSP, orbitosphenoid; P, autopalatine; PE, preethmoid; PF, prefrontal ossification; PM, premaxillary; PPBO, pharyngeal process of the basioccipital; PRO, prootic; PS, parasphenoid (homologue of the mammalian vomer); PTO, autopterotic; PTS, pterosphenoid (pleurosphenoid); PV, prevomer; RO, "rostral" (kinethmoid, *nomen nova*); SOC, supraoccipital; SPH, autosphenotic; V, foramen for the trigeminal nerve; VII, foramen for the facial nerve.

goid and endopterygoid are fused in some specimens, their respective areas being only partially distinguishable, i. e. by their contours.

The large, flat **endopterygoid** (ENT, Figs. 2, 3), together with the ectopterygoid, quadrate, and metapterygoid, forms the mesial wall of the lower half of the orbit. It narrows gradually toward its anterior end, which is the only thick part of the bone, and which slips into two short lateral processes, one on each side of the hind end of the autopalatine, so as to prevent the autopalatine from slipping sideways at its articulation with the endopterygoid.

The middle segment, and greater part, of Meckel's cartilage remains unossified in *N. bifrenatus*. This cartilage cylinder is continuous both rostrad and caudad with cylinders of endochondral bone. The rostral ossification is the **mentomeckelian** (M, Fig. 3), which tapers anteriorly and is fused with the dentary. The caudal ossification is the **articular,** located within the substance of the angular but visible through the more lightly staining semi-transparent dermal bone. In Figure 3 (AR), its position is indicated by the broken lines. Both endochondral bones stain far more deeply than the intimately associated dermal bones, and are, moreover abruptly demarked from the middle unossified segment of Meckel's cartilage.

The ultimate posterior segment of Meckel's cartilage is ossified as the **retroarticular** bone (RA, Figs. 1–3). Although apparently a mixed ossification, its cartilaginous origin is betrayed by the characteristically staining endochondral core, enclosed by a presumably later accretion of superficial bone not preformed in cartilage. The dorsoposterior edge of the small and otherwise nondescript retroarticular fits snugly into the ventral notch of the angular opposite its dorsal articular notch.

The **coronomeckelian** (sesamoid articular) is shaped like half a machine bushing surmounted by a longitudinal vertical flange (SA, Fig. 3). The bushing-like lower part fits over the cylindrical unossified segment of Meckel's cartilage just rostrad of the rostral, exposed end of the articular. The lateral surface of the coronomeckelian, including both vertical flange and bushing-like part, fits into a depression on the mesial surface of the angular, but the coronomeckelian can be dislodged from both Meckel's cartilage and angular.

The **angular** (A, Figs. 1–3) is massive at its hind end, where it engulfs the articular. It has a dorsal notch here for articulation with the quadrate, and opposite this, a ventral notch into which the dorsal edge of the retroarticular fits. The angular extends anteriorly as a thin, trough-like plate between the cylinder of Meckel's cartilage and a trough-like depression on the mesial surface of the dentary. It extends anteriorly to just short of the mentomeckelian; its massive posterior part extends far caudad of the dentary.

The **dentary** (D, Figs. 1–3) is the largest bone in the mandible. It curves mesiad anteriorly, to form a symphysis with its fellow of the opposite side. Laterally, it is surmounted by a perforated bony tubule enclosing a portion of the mandibular lateral-line canal. The tubule is inseparably fused with the dentary and probably represents a splenial (see below under dentary). The dentary sends dorsally a flat, broad, ascending process. This is movably attached to the maxillary so that with the depression of the lower jaw the ascending process of the dentary moves forward and downward carrying with it the posterior end of the maxillary.

The **maxillary** (MX, Figs. 1–6) has a large knob at its anterior end. This fits into the distal concavity of the submaxillary cartilage, the proximal concavity of which fits over the preethmoid. This knob-like condyle is the anchor and pivot of the maxillary. Below the knob, the maxillary (MX, Figs. 3–6) sends mesially a slender rod, which approaches a corresponding rod from the other maxillary. The two rods extend tranversely just behind the ascending processes of the premaxillaries, and thus restrict their movement caudad. With the forward and downward movement of the hind end of the maxillary caused by depressing the dentary, these rods move forward, pushing the premaxillaries before them. The hind end of the maxillary is grooved ventrally, and the groove is flanked mesially by an oval, vertical flange (MX, Figs. 1, 2, 6). The narrow, flat hind part of the premaxillary slides in this groove, and is kept in place by the vertical flange. Except at its anterior end, the maxillary is thin and

flat, and has a broad ascending process much like that of the dentary.

The **premaxillary** (PM, Figs. 1–6) curves mesiad anteriorly to form a symphysis with its fellow. Posteriorly, it tapers and is slightly recurved; anteriorly, it expands dorsoventrally to form a prominent ascending process. The ascending processes of the two premaxillaries are connected by the sigmoid ligament to the "rostral" bone and thence to the anterior end of the ethmoid. The premaxillaries are thus restricted in forward movement by the sigmoid ligament and in backward movement by the mesially directed rods of the maxillaries mentioned above. Their lateral movement is restricted by the lower margins of the maxillaries, which overlap them anteriorly, and by the oval, vertical flanges of the maxillaries which flank their posterior ends mesially.

Hyoid Region

Cartilage bones: paired, **hyomandibulars** (HM), **symplectics** (SY), **interhyals** (IH), **epihyals** (EH), **ceratohyals** (CH), **upper hypohyals** (UH), **lower hypohyals** (LH), unpaired **basihyal** (BH), dermal bones: paired **operculars** (OP), **preopercular**s (POP), **subopercular**s (SOP), **interopercular**s (IOP), **branchiostegals** (BS), unpaired **urohyal** (URH).

The **hyomandibular** (HM, Figs. 1–3) fits above into a facet (Figs. 1–3, 6) contributed to by the pterosphenoid, autosphenotic, autopterotic and prootic. It articulates anteriorly with the metapterygoid, and is attached below to the symplectic, through the intervention of cartilage. It consists of a thick strut of bone with thin flanges extending on either side, rostrad and caudad, respectively. The main strut subdivides above into three branches. The first two form the head which articulates with the neurocranial facet just referred to. The third forms the rounded condyle for the articular facet of the opercular. On the mesial surface of the bone, at the confluence of the three branches with the main strut, there is a large foramen, which leads into a canal running lengthwise within the main strut, and opening on the lower lateral surface of the bone by an oval foramen. The hyomandibular branch of the facial nerve enters the

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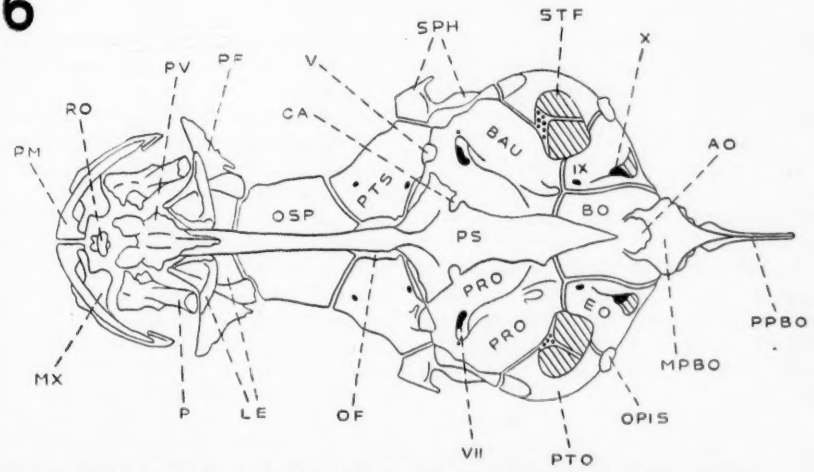


Fig. 6. Ventral view of the skull of *N. bifrenatus* after removal of the same bones as in Fig. 5.

AO, canal for aorta in basioccipital; BAU, bulla acustica utricularis; BO, basioccipital; CA, foramen for carotid artery; EO, exoccipital (lateral occipital); LE, lateral ethmoid; MPBO, masticatory process of the basioccipital; MX, maxillary; OF, optic foramen; OPIS, opisthotic (intercalary); OSP, orbitosphenoid; P, autopalatine; PF, prefrontal ossification; PM, premaxillary; PPBO, pharyngeal process of the basioccipital; PRO, prootic; PS, parasphenoid (homologue of the mammalian vomer); PTO, autopterotic; PTS, pterosphenoid (pleurosphenoid); PV, prevomer; RO, "rostral" (kinethmoid, *nomen nova*); SPH, autosphenotic; STF, subtemporal fossa; V, foramen for trigeminal nerve; VII, foramen for facial nerve; IX, foramen for glossopharyngeal nerve; X, foramen for vagus nerve.

mesial foramen (not shown) and emerges from the oval foramen (FNCE, Fig. 2). It gives off the ramus opercularis superficialis, which leaves the hyomandibular bone through a foramen beneath the opercular condyle, and enters another in the anterior edge of the opercular.

The **symplectic** (SY, Figs. 2, 3) fits in a groove on the dorsal surface of the posterior extension of the quadrate. Its anterior end is inserted between this extension and the fan-shaped part of the quadrate. A thin lamella of bone connecting the hind edge of fan with the posterior extension hides the tip of the symplectic from lateral view.

The small, somewhat cylindrical **interhyal** (IH, Figs. 2, 3) is connected at one end with the cartilage between hyomandibular, symplectic, and metapterygoid and at the other end with the cartilage extending to the upper end of the epihyal.

The **epihyal** (EH, Figs. 2, 3) is a thick, rounded, trianguloid bone. Its apex is directed dorsolaterally toward the interhyal, and its base is broadly articulated with the posterior end of the ceratohyal.

The **ceratohyal** (CH, Figs. 1–3) is very broad lateroposteriorly where it joins the epihyal. It then narrows, but finally broadens out again at its mesial end, where it terminates in two heads. The dorsal head articulates with the upper hypohyal, the ventral head, with the lower hypohyal.

The **upper hypohyal** (UH, Figs. 2, 3) is a curved subcylindrical rod articulating at one end with the ceratohyal and at the other with the lower hypohyal.

The **lower hypohyal** (LH, Figs. 1–3) is a thick V-shaped bone, one limb of which articulates with the upper hypohyal, the other, with the ceratohyal. Its medial surface joins in the midline that of its fellow of the opposite side.

The **basihyal** (BH, Figs. 1–3; glossohyal, copula I, symbranchial I) is a rather flattened, four-sided bar, slightly deeper anteriorly. It extends toward the first basibranchial caudad, and lies just above the junction of the two lower hypohyals. Rostrad it projects free; caudad it is closely attached to the dorsomedial surfaces of the upper hypohyals and to the rostral end of the first basibranchial.

The **urohyal** (URH, Fig. 3) is essentially a broad, flat, horizontal plate surmounted by a longitudinal, vertical plate. Anteriorly, it becomes narrower, thicker and rounder in contour, terminating in two lateral heads separated by a deep vertical cleft. De Beer (1937: 130) listed several synonyms of this bone, and asserted that it may be the homologue of the parahyoid of *Polypterus* and amphibia.

The three, flat, curved **branchiostegals** (BS, Figs. 1, 2) are displaced in Figure 2 to disclose their shapes. Each of them is slightly produced anterodorsally where it articulates with the hyoid apparatus. The first two articulate with the ceratohyal, the third, with the epihyal.

The lunate **preopercular** (POP, Fig. 1) overlies the lower posterolateral surface of the hyomandibular, the hind ends of quadrate and symplectic, the interhyal, the upper lateral surface of the interopercular, and the anterior edge of the opercular. It encloses the preopercular-mandibular laterosensory canal in a bony tube, very irregularly perforated along its lower margin.

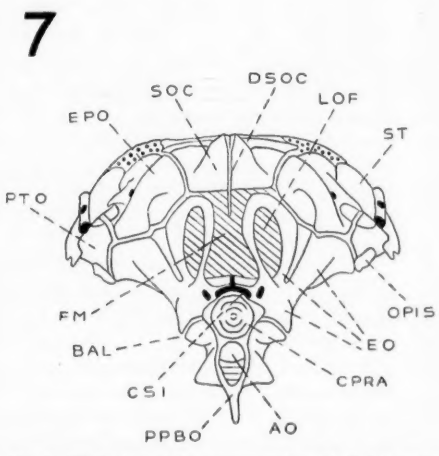
The trianguloid **interopercular** (IOP, Fig. 1) has a slightly incurved upper edge. It overlaps the lateral surface of the ceratohyal and that of the anterior end of the subopercular, and is in turn overlapped anterolaterally by the preopercular.

The **subopercular** (SOP, Fig. 1) has a slightly concave upper, and a moderately convex lower margin. Truncated anteriorly and with a sharp anterodorsal angle, it gradually narrows to a point behind. It is overlain anteriorly by the interopercular and dorsally by the lower edge of the opercular. All bones of the opercular series are mesially concave and laterally convex.

The **opercular** (OP, Fig. 1) is the most complex of the series, with its greatest complexity mesially. The bone is thin and shell-like except for two thick, mesial struts, one along the anterior edge the other diverging from the first ventroposteriorly, at the articular facet for the hyomandibular. The thickened anterodorsal angle of the opercular (suprapreopercular process of Tretiakov, 1945; opercular arm of Nelson, 1949) is generally presumed to have evolved in connection with the insertion of the dilatator operculi muscle. The anterior strut makes the entire leading edge of the bone in-

flexibly rigid, including this process for the muscle insertion. On the anterior edge of the strut just below the suprapreopercular process is the socket for the opercular knob of the hyomandibular, serving as a fulcrum for the dilation of the opercular. Just below the socket, the anterior face of the strut is perforated by two foramina (indicated in Figure 1 by dots slightly exaggerated to show laterally). These foramina receive the two branches of the ramus opercularis superficialis VII, which bifurcates upon its emergence from the foramen in the hyomandibular beneath the knob. A single foramen may often receive both branches. The upper branch proceeds from its foramen through a canal piercing both struts just beneath the socket to open on the mesial surface of the opercular. This upper branch of the ramus then bifurcates, both branchlets giving off several twigs which pass from the mesial side of the opercular, through four to five foramina in the flat part of the bone, to innervate about twenty sensory organs scattered over the lateral surface of the upper third of the bone. The lower branch of the ramus proceeds ventrad from its foramen, parallel with but a little back from the anterior edge of the bone. The course of the nerve is apparent to lateral view as it is enclosed by a superficial lamella of the opercular in a thin-walled bony tubelet reminiscent of the tubular laterosensory canal bones. The nerve emerges from the lower end of this tubelet, midway between the articular socket and the ventral border of the opercular, to supply nine sensory organs along the surface of the bone parallel with and near its anterior edge, and nineteen more bordering on but beneath its ventral edge.

These details of the cyprinid opercular have hitherto escaped notice, but may yet prove of taxonomic utility. Early studies of the cyprinid nervous system (Büchner, 1835; Stannius, 1849) fail to mention the ramus opercularis superficialis VII, the ramus opercularis of Stannius being equivalent only to the ramus opercularis profundus (Herrick, 1899: 297). The penetration of the opercular by the ramus opercularis superficialis VII and its division



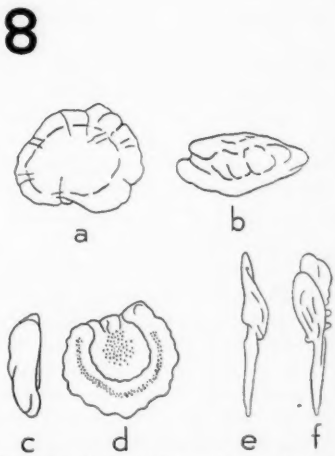


Fig. 7. Hind view of the neurocranium of *N. bifrenatus* after removal of parietals, extrascapulars, posttemporals and supracleithra.

AO, canal for aorta in basioccipital; BAL, bulla acustica lagenaris; CPRA, centrum of proatlas vertebra (basioccipital); CSI, cavum sinus imparis; DSOC, intramembranous spine of supraoccipital (= dermosupraoccipital?); EO, exoccipital (lateral occipital); EPO, epiotic; FM, foramen magnum; LOF, lateral occipital foramen; OPIS, opisthotic (intercalary); PPBO, pharyngeal process of the basioccipital; PTO, autopterotic; SOC, supraoccipital; ST, supratemporal-intertemporal (supratemporal-intertemporal-membranopterotic).

Fig. 8. The left otoliths of *N. bifrenatus*. Unless otherwise specified, they are oriented with their anterior edges toward the top of the figure, and with their left (lateral) surfaces toward the left side of the figure. Abbreviations: a, lapillus (utriculith), dorsal view; b, lapillus, anterior view; c, asteriscus (lagenalith), dorsal view; d, asteriscus, mesial view; e, sagitta (sacculith), dorsal view; and f, sagitta, mesioventral view.

into dorsal and ventral branches was first noted in *Menidia* (Herrick, 1899: 294, and plate XVII), in which the sensory organs and constituent fibers of the two branches differ somewhat from their disposition in *N. bifrenatus*, however. The ramus under consideration seems to be absent from *Ameiurus* (Herrick, 1901: 198). The radial grooves on the operculum of *Carassius* (Koh, 1931: 67) doubtless correspond with the radial striations on the operculum of *N. bifrenatus* found in relation with the nerve branchlets innervating the sensory organs on its surface. The disposition of this ramus and of its ramifications has recently been described in several cyprinids (Lekander, 1949, esp. fig. 11) where details agree closely with those in *N. bifrenatus*.

A suprapreopercular bone (see below under synonymies) is lacking in *N. bifrenatus*.

Branchial Region

Cartilage bones: paired **pharyngobranchials** (PB), **epibranchials** (EB), **ceratobranchials** (CB), **hypobranchials** (HB), unpaired **basibranchials** (BB); ossified **gillrakers.**

The suspension of the **pharyngobranchials** (PB), Fig. 2; unlabelled, Fig. 3) from the parasphenoid has been noted. Only two pairs of pharyngobranchials ossify in *N. bifrenatus*; these are followed behind by a pair of cartilage elements. The same condition was found in *Carassius* by Koh (1931: 72), who considers the second bony pair to represent the second and third pairs of pharyngobranchials, and the cartilage elements, the fourth. This is compatible with the ontogenetic studies of Hubendick (1942: 16 and fig. 12) on *Leuciscus*. The pharyngobranchials of *N. bifrenatus* are shoe-shaped. Each one is overlapped ventrally by the hind end of the preceding one. On each side, the inner heads of the first two epibranchials articulate with the first pharyngobranchial, that of the third with the posterior end of the fused second and third, and that of the fourth with the cartilaginous fourth pharyngobranchial.

The first four **ceratobranchials** and **epibranchials** (CB, EB, Fig. 3) are thin and trough-shaped, with the convex side of the trough directed mesiad. The upper ends of the epibranchials and the lower ends of the ceratobranchials are thickened to form articular heads; their opposite ends are thin. The ceratobranchials articulate below with the hypobranchials. The third and fourth epibranchials have caudally directed uncinate processes. A fifth epibranchial is not evident, although Hubendick (1942: 19, 31, and fig. 13) described in *Leuciscus* a cartilaginous fifth epibranchial, serving as a link between the pharyngeal bone and the cucullaris profundus muscle (trapezius of Takahasi, 1925).

The fifth ceratobranchials (pharyngeal bones) are longer and more massive than the preceding ceratobranchials, and each bears a row of four pharyngeal teeth (PH, Fig. 3). Inferiorly, they join both each other and the cartilage extending caudad from the third basibranchial.

There are three pairs of osseus, comma-shaped **hypobranchials** (HB, Fig. 3), adjacent respectively to the first, second and third basibranchials. There is no trace of fourth hypobranchials in *N. bifrenatus* nor in *Carassius* (Koh, 1931: 72), although they occur as transitory rudiments (Hubendick, 1942: 16) in the ontogeny of *Leuciscus*.

There are three cylindrical bony **basibranchials** (BB, Fig. 3), tending to have their smallest diameter midway between their ends. From behind the last one, a long slender cartilage extends to the ventromesial ends of the fourth and fifth ceratobranchials. The three basibranchials articulate end to end, the rostral end of the first articulating with the caudal end of the basihyal. Their connections with the hypobranchials have been noted.

The tips of the **gillrakers** (not figured) are ossified on all five branchial arches. They are disposed in both a mesioanterior and a mesioposterior row on each of the first four arches of either side, but in a mesioanterior row only on the fifth arch. On the first arch, there are six in the anterior row and eleven in the posterior row, on the second arch, twelve in each row, on the third, twelve and eleven, respectively, on the fourth, eleven and six, and on the fifth, seven in the anterior row. These counts were made on one side of one specimen only.

Selected Annotated Synonymy of Teleost Skull Bones

Angular, A, (e. g. of de Beer, 1937; Devillers, 1947; Lekander, 1949; dermarticular of Goodrich,

1930), the ectosteal (membranous) component of the compound bone known conventionally as "articular". Histology (Haines, 1937) and embryology (Lekander, 1949: 82) confirm the invasion of Meckel's cartilage by the angular to the partial or total suppression of the true articular, although Berg (1940: 416) preferred to retain the old name, "articular."

Articular, AR, ("true articular" of Haines, 1937), the endochondral and/or perichondral (i. e. endosteal) ossification of the penultimate, posterior segment of Meckel's cartilage. The angular replaces the articular in the more differentiated fishes, but it is often hard to determine whether one, the other, or both angular and articular are present in the compound "articular" (Lekander, 1949: 83).

Autopalatine, P, (e. g. of Goodrich, 1930: 284; Gregory, 1933; Ramaswami, 1948: 526), the anteriormost bone of the pterygoquadrate arch, as distinct from the sometimes associated dentigerous, membranous component (dermopalatine).

Autopterotic, PTO, (e. g. of Devillers, 1947: 29; pterotic of Gregory, 1933; and of de Beer, 1937), the cartilage bone component of the "pterotic," in contact with the lateral semicircular canal. The autopterotic is called opisthotic by Holmgren and Stensiö (1936: 482, 486, 490) and Lekander (1949), who considered it to be the homologue of the dorsal half of the opisthotic of *Polypterus*.

Autosphenotic, SPH, (e. g. of Holmgren and Stensiö, 1936: 490, 494; Lekander, 1949; sphenotic of Gregory, 1933; de Beer, 1937; Ramaswami, 1948), the cartilage bone occupying the postorbital (sphenotic) process, as distinct from the dermosphenotic (see below). Without this distinction much confusion has arisen from the difference.

Basisphenoid, (e. g. of Gregory, 1933: 89; suprasphenoid of Kindred, 1919: 37, 73), phylogenetically a cartilage bone but ossifying ontogenetically without cartilage preformation (de Beer, 1937: 129, 140). Lacking in Cypriniformes (Ostariophysi) according to Sagemehl (1891: 496) and Berg (1940: 442); but according to Holmgren and Stensiö (1936: 489) present in cyprinoids, the pedicel only developing, and often fused to the parasphenoid, e. g. in *Abramis*. According to Kindred (1919) and de Beer (1937), present also in *Ameiurus*. Absent in *Carassius* (Koh, 1931, "basi-occipital") and in homalopterids (Ramaswami, 1948: 522).

Coronomeckelian, SA, (e. g. of de Beer, 1937; Lekander, 1949: 80; sesamoid articular of Ridewood, 1904a; Starks, 1916; Haines, 1937; sesamoid angular of Ramaswami, 1948: 528; *Os Meckeli* of Berg, 1940: 427 and fig. 129). Although classified by de Beer and Berg as a cartilage bone, Haines (1937) found it to be a detached portion of the teleost angular (as named here), invariably concerning the insertion of the fibers of the adductor mandibulae, but having no necessary connection with the perichondrium. Coronomeckelian is preferred here to avoid further use of the names articular and angular, although Ramaswami's name is perhaps more apt.

Dentary, D, (dental), the largest dermal bone of the mandible, a part of the bone complex, dental-splenial-mentomandibular, according to Holmgren and Stensiö (1936), Pehrson (1944), Lekander (1949). The objection of de Beer (1937: 125) to the name dentalo-splenial is overcome with the demonstration by Lekander (1949: 125) that splenials in cyprinids may arise separately, either fusing later with the dental or remaining free. The anterior third of the dentary is typically fused with the ossified tip of Meckel's cartilage, known as the mentomeckelian (de Beer, 1937) or mentomandibular ossification (Holmgren and Stensiö, 1936; Lekander, 1949).

Dermosphenotic, DSPH, (e. g. of Gregory, 1933: 88; Holmgren and Stensiö, 1936: 494; Devillers, 1947: 47; Tretiakov, 1946; Berg, 1940, figs. 58, 72, 92, 98, 111, 122, etc.; the triradiate "post orbital 2" of Ramaswami, 1948), the dermal representative of the autosphenotic, bearing part of the suborbital latero-sensory canal (sometimes the conjunction of temporal, supra- and suborbital canals), contributing by its anteroventral corner to the margin of the orbit, and in its maximum development roofing the lateral temporal fossa. In more active cyprinids, dermosphenotic and adjacent suborbitals tend toward regression and disappearance in connection with the protraction of the lateral temporal fossa to accommodate a more robust adductor mandibulae (Tretiakov, 1946). The name sphenotic has been used for either or both the dermo- and autosphenotic. The names postfrontal and intertemporal are wrongly synonymous with dermosphenotic. De Beer (1937: 498) correctly asserted that the postfrontal never was the dermal representative of the sphenotic, since the tetrapod postfrontal was mistakenly homologized with the fish 'sphenotic' before the distinction between membrane and cartilage bones, so that with the distinction, the membrane bone became wrongly named postfrontal. However, he erroneously identified the intertemporal as "the representative of the sphenotic" and the postfrontal as "the uppermost bone in the postorbital series." His intertemporal can be accepted as an intertemporal, but it is not the equivalent of the dermosphenotic! It is the dermosphenotic which is the uppermost bone of the postorbital series, whereas the tetrapod postfrontals are represented in fishes by the supraorbitals (Gregory, 1933: 88). In *Tarpon* (Gregory, 1933, fig. 31), the postfrontal is contiguous anterodorsally with the dermosphenotic. In the figure of

Osteolepis (Goodrich, 1930: 286) alluded to by de Beer (1937: 498), if dermosphenotic is read for postfrontal the discrepancy vanishes. In cyprinids (Tretiakov, 1946), the *apparent* uppermost bone in the suborbital series may be either dermosphenotic (SO_6), suborbital 5, or suborbital 4. In *Salmo*, a dermosphenotic is figured by Gregory (1951: 201, fig. 9.33D), although Berg (1940: 425) denied its occurrence in the Salmonini. Tretiakov's dermosphenotic is the same as Gregory's, and the penultimate bone in Tretiakov's series (our SO_5) seems to be de Beer's postfrontal, the presumption being that the dermosphenotic was lacking in de Beer's as in Berg's specimens of *Salmo*. That a bone in this position may upon occasion represent at least in part the postfrontal is shown by the paleoniscoid, *Coccocephalus* (Gregory, 1951: 179, fig. 9. 6C), in which the penultimate suborbital and hindmost supraorbital seem to be confluent, but such a bone could only become the *apparent* uppermost bone in the suborbital series, i. e. through suppression of the dermosphenotic. In *Leptolepis bronni* (Berg, 1940: 418, and figs. 111 and 113, after Rayner), two supraorbitals, a dermosphenotic, and a supratemporal-intertemporal are present, so that dermosphenotic and intertemporal can not be regarded as valid synonyms either.

Dermosupraoccipital, DSOC?, the dermocranial covering of the endocranial supraoccipital (tectum synoticum) according to Gregory (1933: 89), who does not equate it with the extrascapulars. Goodrich (1930: 283) is less explicit as to its use: "postparietal (dermosupraoccipital) which with (*sic*) the tabulars may form a transverse row of bones sometimes called supratemporals." Berg (1940, figs. 66 and 68) used the names postparietal and dermosupraoccipital interchangeably for superficial bones of the occipito-parietal region apart from the extrascapulars (tabulars) and not enclosing the transverse occipital lateral line canal.

Ethmoid, E, the bone ossifying in and around the nasal septum. The name mesethmoid should be rejected because of implications of homology with the mammalian mesethmoid (Gregory, 1933: 88; de Beer, 1937: 442), and because of its application to a dorsally contiguous dermal element (e. g. by Starks, 1926).

Extrascapular, PP, one of a series of from two to eight bones of the teleost skull, known variously as cervicals, extrascapulars, nuchalia, postparietals, scale bones, supratemporals, or tabulars (cf. review by Tretiakov, 1945: 52). Their relations to adjacent bones are diverse and their homologies are not well established. The logical name (supratemporal) of each element of the series is preempted by its application to the dermal (tube bone) representative of the autopterotic, as Tretiakov notes in preferring the name tabular. He identifies them by their connection with the supratemporal commissure (transverse occipital latero-sensory canal), and infers from their frequently reduced number mutual fusion or growth to subjacent bones. According to him, the lateral extrascapular (tabular) retains its independence more often than the others, and may be recognized by the conjunction within it of temporal (postorbital), supratemporal, and posttemporal canals. In cyprinids, the lateral extrascapular has often been called the postparietal, but de Beer (1937) applied the name postparietal in a less restricted sense to the several members of the series, and postparietal seems also to be the synonym of dermosupraoccipital (see above). The names most frequently and unequivocally employed are extrascapular and tabular. Most commonly there are two such bones on either side of the skull, a mesial (or median) extrascapular (middle tabular) and a lateral extrascapular (lateral tabular), such a condition occurring widely, e. g. in *Acentrophorus*, *Chanos* and *Cyprinus*. Among cyprinids, Tretiakov found tube bones free and separate, mutually fused, or fused with parietals or adjacent bones. Ontogenetic studies (Devillers, 1947: 31; Lekander, 1949: 87) show, moreover, that the extrascapulars often arise *ab initio* as discrete entities, only later fusing with other bones. Thus the old dilemma (cf. Allis, 1904: 437; de Beer, 1937: 495, 506, 513) concerning the homologies of the components of the "parieto-extrascapular" is resolved.

Intertemporal, (see supratemporal-intertemporal).

Jugal, may be represented by suborbital 2 (SO_2) according to Gregory (1933: 88) and de Beer (1937: 124). An anatomical criterion is the attachment to the mesial surface of the bone, in conjunction with a ligament from the hyomandibular, of the M. adductor maxillaris, a division of the M. adductor mandibulae (Chabanaud, 1945: 570).

Lachrymal (lachrimal, lacrimal, lacrymal, preorbital, SO_1), L, usually the foremost bone in the suborbital series in teleosts, and the homologue of the lachrymal of *Cheirolepis* and of tetrapods, but not of the antorbital of *Amia* (Gregory, 1933: 89, 93). The foremost bone in this series in *Salmo* is called lachrymal-antorbital by Holmgren and Stensiö (1936: 494), but Devillers (1947: 11) objected to this, asserting that it has none of the characteristics of the latter element. On the other hand, Lekander (1949) used the name antorbital for the bone in cyprinids called lachrymal here and by Devillers. Among homalopterids, Ramaswami (1948) described a lachrymal-jugal present simultaneously with an antorbital.

Lateral ethmoid, LE, (parethmoid, ectethmoid, erroneously called prefrontal), the bone arising on each side in relation to the cartilage of the lamina orbitonasalis, according to de Beer

(1937: 107), who reserved the name ectethmoid for the ossification at the same locus independently evolved in birds. Berg (1940: 446) mistakenly equated the prefrontal (membrane bone) and lateral ethmoid (cartilage bone).

Membranopterotic, (see under supratemporal-intertemporal).

Mentomeckelian (mentomandibular), M, (see under dentary).

Opisthotic (intercalary), OPIS, phylogenetically a cartilage bone, often all that remains of it being an ossified ligamentous extension completely excluded from the auditory capsule according to de Beer (1937: 130), who accepted the interpretation of Sagemehl (1891: 558), who described this condition among cyprinoids. Holmgren, Stensiö, and Lekander applied to it the name intercalary, but reserved the name opisthotic for the autopterotic as named here (see under autopterotic). Berg (1940) used the names opisthotic and intercalary both as synonyms (pp. 419, 434) and not as synonyms (pp. 412, 414).

Parasphenoid, PS, homologue of the mammalian vomer (Gregory, 1933: 89).

Postfrontal, (see under dermosphenotic).

Posttemporal, PTT, the bone articulating with the epiotic, suspending the pectoral girdle, and traversed by the posttemporal lateral line canal. De Beer (1937: 125) called such a bone "suprascapular (supracleithrum)" in *Salmo*, "posttemporal" in *Ameiurus* (p. 139), and "posttemporal (supracleithrum)" in *Amia* (p. 105). This confusion stems perhaps from the nomenclature of Haller (1905), in which the upper of the two bones traversed by the posttemporal canal was called the second supracleithrum, and the lower, the first supracleithrum. Haller's first supracleithrum articulates with the cleithrum and should be called simply the supracleithrum; his second supracleithrum is known to most authors as the posttemporal, as named here.

Preethmoid, PE, (e. g. of Starks, 1926; and cf. Ramaswami, 1948: 516), the bone called septomaxillary by Sagemehl (1891) but renamed by Swinnerton (1902: 530) in view of the dubious homology of these bones with the tetrapod septomaxillaries.

Prefrontal, PF, the membrane bone extending laterad from the lamina orbitonasalis (cartilaginous precursor of the lateral ethmoid) of each side, and which in teleosts may be absent, separate, fused from the beginning with, or developed as an extension of, the lateral ethmoid (de Beer, 1937: 500).

Prevomer, PV, the homologue of the tetrapod prevomer (Gregory, 1933: 88; de Beer, 1937: 433), although often incorrectly called vomer, the parasphenoid rather being the teleostean homologue of the mammalian vomer.

Pterosphenoid (pleurosphenoid), PTS, for the so-called "alisphenoid" of teleosts (cf. Gregory, 1933: 98). With the recognition of the non-homology of the mammalian alisphenoid with the "alisphenoids" of either teleosts or birds and reptiles, the reptilian "alisphenoid" became known as the pleurosphenoid. De Beer at first (1926: 366) used the name pterosphenoid for the teleost "alisphenoid" presumably agreeing with Goodrich (1930: 380) that the fish bone was not the exact homologue of that of birds and reptiles. Later (1937: 439) he reverted inexplicably to the use of pleurosphenoid for the fish bone merely with the statement that "the bone in question in these forms has occasionally been known as the pterosphenoid pending the demonstration of its homology with the pleurosphenoid." Unfortunately the name alisphenoid is still often applied to this bone in fishes.

Retroarticular, RA, (e. g. of Böker, 1913: 387; Haines, 1937; de Beer, 1937: 128; Ramaswami 1948; dermarticular of Holmgren and Stensiö, 1936: 496 and fig. 373; dermarticular plus retroarticular? of Lekander, 1949), the bone conventionally known as the angular. The retroarticular is a mixed ossification, with a core of endochondral bone formed in the ultimate, posterior segment (retroarticular process) of Meckel's cartilage overlain by dermal bone (the latter probably the equivalent of Lekander's dermarticular).

"Rostral," RO, (e. g. of Sagemehl, 1884; Starks, 1926; supraethmoid of Koh, 1931; preethmoid of Edwards, 1926), the sesamoid bone typical of cyprinoids and involved in the mechanism for the protrusion of the premaxillaries (cf. Gregory, 1933: 185; Eaton, 1935). All names so far used for this bone are preempted by their applications to other bones. The name "kinethmoid" (Gr. ***kinein***, to move, plus ethmoid) is therefore proposed here for the cyprinoid "rostral," a movable bone of the ethmoid region.

Squamosal, the name used by Sagemehl (1891: 506) for the "pterotic" complex of cyprinoids, and unfortunately still applied occasionally to the teleost skull, although Westoll (1937) and others have shown that the true squamosal is absent from the Actinopterygian skull, having disappeared with the retirement of the jugal canal from the status of lateral-line canal to that of pit line.

Suborbital, SO, (e. g. of Gregory, 1933; de Beer, 1937; Ramaswami, 1948; infraorbital of Holmgren and Stensiö, 1936; Moy-Thomas, 1938: 307; Lekander, 1949; Devillers, 1947), any one of the series of bones (lachrymal, jugal, postorbital, dermosphenotic, etc.) associated with the suborbital (infraorbital) lateral-line canal. Among teleosts, the most usual number in this series is six bones, although departures from this number,

even within the same fish, render homologization of individual bones uncertain.

Supracleithrum, SCL, (see under posttemporal).

Supraethmoid, SE, (e. g. of de Beer, 1937; Ramaswami, 1948; dermal ethmoid, dermethmoid, dermal mesethmoid, mesethmoid of various authors). Berg (1940, fig. 127) retained the name mesethmoid for the dermal ethmoid, and used hypethmoid for the "unpaired bone below the dermal mesethmoid" (p. 425), but the name mesethmoid should only be applied to the mammalian skull (see under ethmoid), and hypethmoid appears to be a synonym for ethmoid as defined above.

Supraorbital, SPO, one of the one or more bones along the upper margin of the teleost orbit, not traversed by a laterosensory canal, and according to Gregory (1933: 88) including the postfrontal. The confusion of postfrontal and dermosphenotic becomes understandable from an examination of such skulls as those of *Cheirolepis* and *Coccocephalus* (Berg, 1940, fig. 52; Gregory, 1951, fig. 9.6), in which the hindmost supraorbital (postfrontal) seems to be confluent in the one case with the uppermost bone of the suborbital series (dermosphenotic) and in the other, with the bone just beneath the dermosphenotic. Supraorbitals apparently only thus come to acquire relationships with the laterosensory system.

Suprapreopercular, (e. g. of Allis, 1910: 152; Holmgren and Stensiö, 1936: 495; Berg, 1940: 403, 413, 423, 428, fig. 146, "s. pr. op."; Tretiakov, 1945; Devillers, 1947: 11, 36, 38; Lekander, 1949: 69, 102; supraopercular of Bruch, 1861: 12; supratemporal of Parker, 1873: 99; "subtemporal or supraopercular" of Ridewood, 1904b: 485; subtemporal of Kindred, 1919: 94; and of de Beer, 1937: 125; "subtemporal" of Gregory, 1933: 166, supratemporal, p. 165, "sbtm," fig. 59). The name suprapreopercular is applied to any of from one to several usually small tube bones conducting the dorsal extension of the preopercular laterosensory canal across the gap between the preopercular bone and the supratemporal canal above. These bones are considered to represent vestiges of the upper half of the bipartite preopercular (suprapreopercular plus infrapreopercular) of, e. g., Paleoniscoids, Bobasatraniidae, Pycnodontiformes, Phractolaemoidei and Chanoidei (Stensiö, 1932, 1947: 184; Tretiakov, 1945: 49), the infrapreopercular being represented by the preopercular as usually understood. Among salmonoids and cyprinoids, suprapreopercular elements tend to be absent or vestigial, and when present in cyprinids, exist as free tube bones or may fuse with the anterodorsal corner of the operculum, the latter condition being peculiar to cyprinids, according to Tretiakov. The skull of *Notemigonus c. crysoleucas* has such an opercular, and the same condition is recorded for a few other cyprinids (Allis, 1904: 437, fig. 17; Devillers, 1944; Tretiakov, 1945).

Supratemporal-intertemporal, ST, (e. g. of Holmgren and Stensiö, 1936: 490, 494; Berg, 1940: figs. 92, 97, 111; Bamford, 1941; Devillers, 1947: 29; Lekander, 1949: 69, 71, 85, 103; supratemporal and/or intertemporal of de Beer, 1937: 132, 139; "pterotic" or supratemporal of Gregory, 1933: 92; squamosal in part of Kindred, 1919; in part, the dermosquamosal of other authors). In cyprinids, the pterotic complex or pteroticum (squamosal of older authors), in addition to the cartilage-preformed autosphenotic (as named here), consists according to Devillers and Lekander of (1) a flat membranous bone (membranopterotic or dermopterotic), which may be fused from the beginning with the autopterotic or may fuse to it later; and (2) several tubular canal bones (one or two intertemporals and one supratemporal), which either remain free or fuse with the membranopterotic. The ectosteal complex might thus be called a supratemporal - intertemporal - membranopterotic but is usually referred to as the supratemporal-intertemporal, as here. The entire pteroticum may therefore be designated the supratemporal-intertemporal-autopterotic. Except for their relation to the temporal laterosensory canal and for the more anterior position of the intertemporal, the intertemporal and supratemporal bones have often been only vaguely characterized. The confusion of intertemporal and dermosphenotic has been noted (see under dermosphenotic). Ramaswami (1948: 518) identified the intertemporal as the canal bone opposite the sphenotic gap, asserting (p. 520) that in the majority of cases the intertemporal is associated with the sphenotic and the supratemporal either fused with the "pterotic" or located above it. Devillers (1947: 30) recalled that phylogenetically the line of demarcation between the two bones was the junction point of preopercular and horizontal canals. In cyprinids, the intertemporal portion of the temporal canal is associated with two neuromasts innervated by the ramus oticus facialis, whereas the supratemporal portion is associated with two neuromasts innervated by the glossopharyngeal (Devillers, 1947; Lekander, 1949).

The writer did most of this work while on the faculty of Trinity College, Hartford, Connecticut.

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Chacoan Batrachians in Central Argentina

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THE batrachian fauna of the Central Chaco is presently defined (Freiberg, 1942; Vellard, 1946) according to the physiography and climate of the extensive level region between the Pilcomayo and Teuco Rivers (22° and 26° South Lat.). Its components are as follows.

Bufo paracnemis Lutz
Bufo granulosus d'orbignyi Dumeril and Bibron
Bufo arenarum Hensel
Ceratophrys ornata Bell
Ceratophrys (= *Stombus*) *pierottii* Vellard
Odontophrynus americanus Dumeril and Bibron
Odontophrynus cultripes
Lepidobatrachus asper Budgett
Leptodactylus podicipinus Cope
Leptodactylus ocellatus Linnaeus (near the Paraguay River)
Leptodactylus chaquensis Cei
Leptodactylus bufonius Boulenger (Burrower)
Leptodactylus prognathus Boulenger (Burrower)
Leptodactylus sybilator Wied (Burrower)
Leptodactylus mystaceus Spix (Burrower)
Leptodactylus gracilis Dumeril and Bibron (Burrower)
Leptodactylus laticeps Boulenger (Burrower)
Physalaemus fuscomaculatus Steindachner
Physalaemus cuvieri Fitzinger
Pseudis paradoxa Linnaeus
Pseudis limellum Cope
Pseudopaludicola falcipes Hensel
Hyla phrynoderma Boulenger
Hyla nana Boulenger
Hyla lindneri Müeller and Hellmich
Hyla faber Wied
Hyla venulosa laurent
Hyla nasica Cope
Hyla raddiana Fitzinger
Hyla spegazzinii Boulenger
Phyllomedusa sauvagii Boulenger
Phyllomedusa hypochondrialis Daudin
Dendrophryniscus s. stelzneri Weyenbergh
Dendrophryniscus rubiventris Vellard
Elachistocleis ovalis bicolor Guerin
Hypopachus (= *Dermatonotus*) *muelleri* Boettger

Characteristic forms are especially *Ceratophrys pierottii*, *Lepidobatrachus asper*, the poisonous *Leptodactylus laticeps* (or "rana coralina"), *Leptodactylus mystaceus*, *Physalaemus cuvieri*, the treefrogs *Hyla phrynoderma*, *Hyla nana*, *Hyla lindneri*, *Phyllomedusa hypochondrialis* (which has a wide range from Ceará, Brazil), and *Hypopachus* (= *Dermatonotus*) *muelleri*. These characteristic Chacoan amphibians have been known hitherto from only the northern side of the Teuco River except for a few from the more humid Chacoan border of the Paraná[1], being absent from the extensive and little known region of the cactus and *Prosopis* arid biocenosis between 25° and 28° South Lat., and between 61° and 64° West Long. We have no records of any of these forms from Tucumán and Santiago del Estero (30° South Lat.). However, during the rainy summer season of 1951 and 1952, I found some of these species breeding in the provinces of La Rioja and Cordoba. During the rainy summer season of 1954 and 1955 other specimens were collected in the salt region of Saladillo (Salares: South of Santiago del Estero). The very limited area of their occurrence in this arid part of the Argentine plains ("area central") can be considered as forming a veritable ecological island far removed from the main part of their extensive range north of the Teuco River.

In La Rioja (Fig. 1) I observed little but the characteristic batrachian fauna on the xeric plains of clayey soil near Patquia (Punto de los Llanos), where several specimens of breeding *Lepidobatrachus asper* were collected at night swimming in the temporary pools near the national road during the latter part of March, 1951. All individuals were smaller than those from the Paraguayan and Formosan Chaco, their skins were thinner, and they had a very evident yellow coloration in the inguinal and axillary regions. These smaller individuals are not so aggressive as the larger ones from the Pilcomayo River, do not call, nor do they attack if teased (Plates I and II). In the summer of 1952 (February) in the same temporary pools (Punta de los Llanos) I collected other specimens of *Lepidobatrachus asper*, as well as *Ceratophrys* (= *Stombus*) *pierotti*, *Leptodactylus prognathus* and *Leptodactylus bufonius*. With the exception of *L. prognathus* (which has a wide range in the Argentine) all these species are characteristic of the Chacoan biota. Until the present time the batrachian fauna of

[1] *Leptodactylus laticeps* was recorded from Santa Fé (Boulenger, 1918); *Phyllomedusa hypochondrialis* from Resistencia, Chaco of Santa Fé and Corrientes; *Hyla phrynoderma* from Resistencia, Chaco Austral and Corrientes; *Hyla nana* from Resistencia (Berg, 1896).

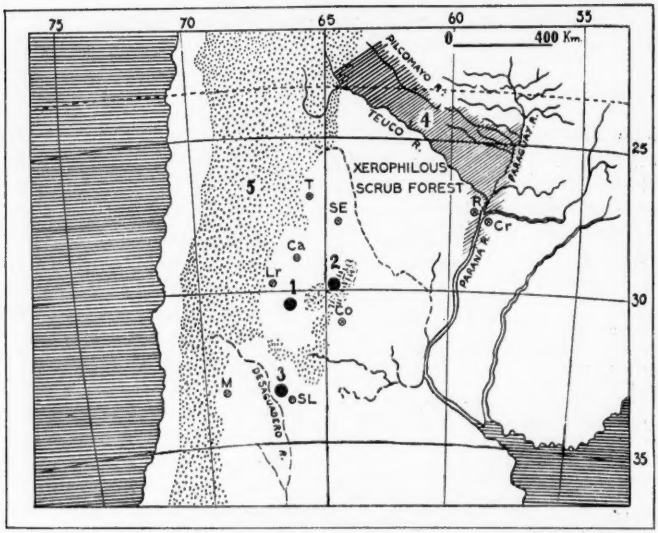

Fig. 1. Map of northern and central Argentina, showing batrachian localities.

1—Area containing relicts of Chacoan batrachian fauna on clayey soil near Punta de los Llanos, La Rioja. 2—Extensive salt plains known as "Salinas Grandes" near Totoralejos, Cordoba. Habitat of *Ceratophrys* (= *Stombus*) *pierottii*. 3—Area of relict Chacoan batrachian fauna on clayey soils near Jarilla, San Luis. 4—Xeric zone of the Central Chaco and the more humid area alongside the Paraná River in the Southern Chaco containing characteristic Chacoan batrachian fauna. 5—Mountainous Andean zone.

T = Tucumán; SE = Santiago del Estero; Ca = Catamarca; Co = Cordoba; R = Resistencia; Cr = Corrientes; SL = San Luis; M = Mendoza.

the province of La Rioja, was known to be composed of only *Bufo arenarum*, *Hyla riojana* Koslowsky (in the high mountains) and *Leptodactylus ocellatus* (Freiberg, *loc. cit.*).

The native arid vegetation of the Punta de los Llanos is abundantly represented by bromeliads, *Prosopis*, *Acacia*, and typical elements of the "central" xerophilous scrub forest, with some subtropical features (Pls. I–II). There are many rodent burrows, especially those of *Kerodon* and allied forms. The entomological fauna is very abundant (hymenopterans, ant, mosquitos, tenebrionids, etc.); in the pools are great numbers of chironomid larvae, oligochetes and entomostracans such as *Branchipus* and *Apus* of large size.

In the province of Cordoba, in the arid plains of the Salinas Grandes (alophilous biocenosis) several hundred breeding *Ceratophrys* (= *Stombus*) *pierottii* were captured (1951, April). This little "escuerzo" was migrating along the national road, near Totoralejos (29°40′ South Lat., 64°50′ West Long.) one day after a storm. They were mating and swimming in the temporary brackish pools situated in the *Salsola*-covered ground of this part of Salinas Grandes. They were very active and pugnacious, showing frequent cannibalism. They do not appear to differ from the *Ceratophrys pierottii* described by Vellard (1946) from Hickman, Central Chaco or from those collected by me at Ing. Juarez, Teuco River, Formosa.

In the temporary summer pools of the xeric flat lands of Saladillo (alophilous biocenosis) a few breeding individuals of *Lepidobatrachus asper*, *Ceratophrys pierottii* and *Pleurodema* sp. (*nebulosa* group?) were captured (1954, January). All adults of *Lepidobatrachus asper* mating were exceptionally small (4.5 cm., snout to vent). Perhaps they represent a local, dwarf race. During the rainy summer season of 1955 these species were taken again and the same ecological observation was made by another observer, Dr. A. Pisanó, from our biology department (April, 4).

Also in the xeric clayey region of San Luis (Jarilla, Alto Pencoso; 15 km. from the Desaguadera River, 33°25′ South Lat., 67° West Long.) I found during the wet season of 1951 (December) a peculiar batrachian fauna with

Upper: *Lepidobatrachus* in attitude of attack; Pilcomayo River, Central Chaco, December, 1948.
Lower: Typical xerophilous scrub forest near Punta de los Llanos, La Rioja, April, 1951.

Upper: Temporary pool formed after rainfall in dry xerophilous clay land; Punta de los Llanos, La Rioja, April, 1951.

Lower: Lepidobatrachus (La Rioja form) in characteristic non-aggressive attitude; Punta de los Llanos, April, 1951.

some Chacoan features (Fig. 1). There were many temporary pools alongside the national road to Mendoza during this exceptionally rainy summer. The following forms were taken: *Leptodactylus bufonius*, *Physalaemus fuscomaculatus*, *Physalaemus* sp., *Ceratophrys ornata*, *Odontophrynus americanus*, *Bufo arenarum*. I observed many subterranean nests of *Leptodactylus bufonius* in the clayey soil, and floating froth nests of *Physalaemus fuscomaculatus* in the pools. There were many social burrows of *Lagidium* ("vizcacheras") in the vicinity, perhaps the shelters of *Leptodactylus bufonius* and *Ceratophrys*, as in the true Chacoan biocenosis. The invertebrate fauna of the pools was very abundant at this period, especially entomostracans (*Apus* and related forms) and dipteran larvae.

Only three species of batrachians were recorded by Freiberg (1942) for the province of San Luis: *Bufo arenarum*, *Hyla raddiana*, *Leptodactylus ocellatus*. My report shows that the fauna of this territory is a transitional one. It is composed of the more ancient Chacoan subtropical elements (ecological relicts in the clayey soil station near Jarilla) and the peculiar Andean fauna of the nearby Mendoza province[2]. It was impossible during the wet summer of 1951 to find the above mentioned forms anywhere between the cañons of the Desaguadero River and the western arid zone of Mendoza.

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[2] On December 5, during the rainy summer season of 1954, many breeding specimens of a characteristic Cordilleran form, *Pleurodema nebulosa* (Burm.), were taken in the clayey plains east of San Luis.

Identification and Ecology of the Toad *Bufo regularis*

R. M. Winston

In Lagos, Nigeria, in 1950 work was begun to establish the Galli-Mainini or male-toad pregnancy test using *Bufo regularis* (Reuss) as the test animal. A biological test can only be established on an adequate knowledge of the test animal, but the only information about *B. regularis* that could be found was a paper by Boulenger (1880) dealing with identification, a note on ecology by Seetzen (1855) and notes on the male by Chhung Hin and Webb (1949) and Hughes (1949). It was necessary, therefore, to study the identification and ecology of *B. regularis*.

Four main sites were chosen for observing *B. regularis*. The first was a large compound at Yaba, 5 miles north of Lagos. This compound was approximately square and contained a lake which became a dry hollow towards the end of the dry season, but which covered several acres during the rains. Surrounding the lake was close-cut grass and at the periphery were buildings dispersed over cultivated ground. Three sides marched with similar compounds and the fourth with a by-road across which lay several acres of dense undergrowth and a pond. The second site, at Oshodi 3 miles north-west of Yaba, consisted of a number of widely separated, ruined huts and laterite roads overgrown with secondary bush. This site contained five large concrete fire tanks at ground level, all full of water, and numerous surface drains. The third site was at Hansa, 7 miles north of Yaba, where a by-road crossed a small, swampy stream, and the fourth site was near Tapa, 4 miles north-east of Yaba. At the fourth site an unfinished road crossed a large swamp fed by the Hansa stream. All four sites were partly wooded. The Yaba and Oshodi sites differed only in undergrowth, and the Hansa and Tapa sites were very similar but differed from the first two. These four areas were visited many times during the 12 months from October, 1950 to

September, 1951. Many other places in and around the area enclosed by the main sites were visited occasionally during the same period. A few observations were made in Kano, about 700 miles north of Lagos, in 1953.

IDENTIFICATION OF *Bufo regularis*.—All the toads which are described in the following pages were identified by the excellent key and description given by Boulenger (1880). He had his doubts, however, about the homogeneity of the species and distinguished two varieties, A and B, from the type. Varietas A, which he thought might be a separate species, he reported as occurring together with the type on the West Coast of Africa. Varietas B he reported as the sole representative of the species in South Africa. The two varieties were distinguished by size, var. A being smaller than the type and var. B larger than the type, but he gave measurements for only two adult males, the type and var. A.

From December 6, 1950 to January 10, 1951 all male toads were measured within 24 hours of capture. Toads with ulcers or deformities, or if wasted or inactive, were rejected, but blindness of one eye, which was common, was ignored. Snout-to-vent measurements were made with a sliding caliper; the mean of three readings of the maximum length to the nearest millimeter was recorded. Weights were measured to the nearest gram. Notes were made of the parotoids, the size of the tympanum relative to the eye, the fingers and the skin color and markings. Males were identified either by the presence of a black pad on the inner aspect of the first finger or by the release of spermatozoa after the injection of urine from pregnant women. Eighty-three males of *B. regularis* were measured. The snout-to-vent length ranged from 54 to 107 mm., with a mean of 82 ± 2 mm. (95 per cent limits). The weight ranged from 15 to 138 g. with a mean of 58 ± 5 g. (95 per cent limits). The correlation coefficient (weight with snout-to-vent length) was 0.89 with 95 per cent limits of 0.84 and 0.93.

Identification of the species was easy. With none of this series of 83 was any difficulty experienced nor was any difficulty experienced subsequently, though more than 700 toads have been identified. The tarsal fold, however, appeared more as an abrupt change of level of the skin than as a fold.

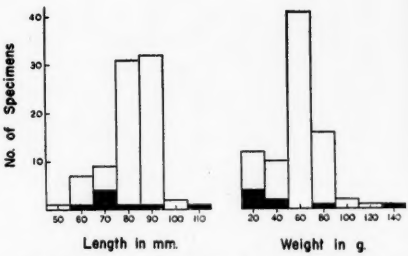

Fig. 1. Snout-to-vent length and weight of 83 males of *Bufo regularis*. The black areas represent toads without sex marks.

The range of 54 to 107 mm. in the snout-to-vent length of males includes the measurement of 69 mm. given by Boulenger for the type but excludes the measurement of 51 mm. given for var. A. His toads, however, were presumably measured after death and nothing is known about their fixation, but my toads were measured alive. Also there must be some variation of var. A if it exists. This series of 83, therefore, may include both var. A and the type. Var. B may also be included because the largest male, 107 mm. and 138 g., was intermediate in length between the two female specimens of the type and the single individual of var. B described by Boulenger.

The possibility of var. B occurring in the Lagos area may be dismissed briefly. Only two males weighing more than 100 g., both in this series of 83, were captured during the year. Males weighing more than 70 g. were always scarce, much scarcer than this series suggests. No site was ever found where even one male weighing more than 70 g. could be found with certainty on any single night. The evidence favors the view that these large individuals were males of the type which had survived a sufficient time to grow large.

Some of the smaller males, however, might have been var. A, and to ascertain if this were so a place was sought where only small ones occurred. Many dissimilar places were searched on consecutive nights at the same hour, but none was ever found where small males occurred in the absence of large ones, or the converse. Small males, however, were commoner at the Tapa site and Hansa, and large ones at Yaba and Oshodi.

As var. A might always occur with the type, evidence from mating was sought. In the early

evening a male of 15 g. was caught in amplexus at Hansa, a female of 130 g., a large one, was caught in amplexus at Oshodi and the two were placed in a sink soon afterwards. Amplexus occurred immediately and continued till the following morning. No ova were laid but special facilities are needed for this to occur. This experiment, often with several pairs, was repeated many times with similar results. In the laboratory a male will clasp any female bigger than himself. In the field the conclusion is not quite so definite, for usually males are found in amplexus with females only a little larger.

The histograms (Fig. 1) show some skewness which may be significant, but the interpretation of any skewness must depend on the method of sampling. The series of 83 consisted of all the males that could be caught; no attempt was made to make a random sample. As will be shown later, a truly random sample of these toads from a large area can scarcely be defined. The definition of maleness, however, was wide. The males without sex marks might be thought to be immatures of the type, but this is unlikely because the largest one caught lacked all sex marks and because well marked males sometimes lose all their sex marks in captivity.

If the smaller males are merely younger ones and not a separate species or variety, it may be expected that their behavior in the field will differ from that of the larger males in such a way that the larger ones have a better chance of survival and breeding. This was found to be so, though no line of demarcation between small and large males could be drawn. Small males emerge from their day-time cover earlier than large ones. Small males are easier to catch than large ones; small ones pay no attention to a bright light and may be picked up in full croak, but large males become silent and flatten themselves to the ground when illuminated. Small males will croak alongside the least puddle of water, useless for breeding, but large ones croak only on the banks of large ponds or slow moving streams. Small males are sometimes found in amplexus with other small males, but large ones are never found in amplexus with others of the same sex.

No useful conclusions could be drawn from a consideration of the notes on the parotoids, the fingers, the size of the tympanum relative to the eye, and the skin color and markings. The variation of these characters was not sufficient to suggest that more than one species or that varieties of one species were being examined.

The final conclusion from these observations and deductions is that var. A and var. B cannot be identified, that only the type exists, in the Lagos area. This does not necessarily conflict with the reports of other observers. My toads were all captured in a few square miles of Africa but Boulenger reported on specimens from Egypt, Port Elizabeth and the West Coast. The males used by Hughes (1949) in the Gold Coast weighed 30 to 50 g. which agrees with the males found near Lagos. The males used by Chhung Hin and Webb (1949) in Mauritius, however, weighed only 20 to 30 g. and Chhung Hin (in litt.) has since reported that he has never seen larger specimens. If his identification is correct (he has not given his criteria), it appears that var. A occurs by itself in Mauritius.

IDENTIFICATION OF SEX.—Boulenger (1880) reported that the throat of *B. regularis* is blackish in males and that blackish rugosities cover the inner surface of the first two fingers during the breeding season. Hughes (1949) used these rugosities or nuptial pads to identify males but Chhung Hin and Webb (1949) relied on the blackish throat.

More than 50 toads with nuptial pads were found to be males by dissection. On two occasions hundreds of toads presumably searching for females were examined and all had nuptial pads. This sign was used to identify males of *B. regularis* for pregnancy diagnosis tests and the accuracy of these tests supports the view that this sign is accurate.

Toads with nuptial pads almost always have colored throats. The color varies from light brown to dark brownish black with the average hue of the dorsal surface, and it usually has a greenish tint. The color is central with a paler edge. In captivity some toads shed their sex marks; the nuptial pads are always shed before the throat color; similar males, without some or all sex marks, can often be found on cultivated ground away from water.

Small females usually have white throats but those of large ones are commonly black. Usually the color is speckled at the periphery with a

pale center, but a few large females have black throats almost indistinguishable from the male.

Rarely toads have conflicting sex marks. Two, captured in amplexus as females, had the typical male throat colour but no nuptial pads. They were placed in a tank with known males and tadpoles were reared from both. Three toads with nuptial pads but white throats were found to have testes and another with nuptial pads, but with a typical speckled female throat, was also found to have testes. In these six toads with conflicting sex marks the nuptial pads always correctly indicated the sex.

Males of *B. regularis* can croak but females can only emit a soft high-pitched hiss. Males may clasp other toads or a finger laid against the ventral surface (the amplexus reflex) but not females. Males are long and narrow; females are short and broad.

From a consideration of the sex marks and reflexes, it is apparent that, although males may be selected with certainty, the accurate selection of females by their external appearance is not yet possible. How identification of sex is accomplished by *B. regularis* in the field, therefore, is of interest.

Pairing of the sexes usually begins at night. Usually the males are heard croaking around a pond. They all have their heads towards the water and none is more than a few feet from the water's edge. After a time the croaking suddenly ceases. The suddenness is dramatic but the silence is soon broken by a single toad which is joined by first one, then another and finally by almost the whole chorus. Almost all the males rejoin the chorus but a few remain silent. Meanwhile the females are crawling towards the males and necessarily approach from behind, usually to one side. When a female is about 30 cm. from a male, if he is silent, he may turn towards her and amplexus may occur, but if he is croaking he pays no attention to her. On one occasion a female was seen crawling towards a male at the water's edge. He stopped croaking and she crawled to about 30 cm. from him, but then she turned sharply away, approached another male and mated with him. The first male did not appear to notice the presence of the female, even though he was silent. These observations were made at night by the light of distant street lights. It seems probable, therefore, that the male indicates his position by his croak and that the female announces her arrival to the male. Females can hiss but if one does announce herself to the male by hissing it is not surprising that this sound was not heard, because the tropical night is full of high-pitched noises from innumerable insects.

Twice during the year of observation males of *B. regularis* were found searching for females. The males were in the majority, the females were quiescent; the males were light brown and the females were very dark. Also on both these occasions pairing occurred in daylight. The males were extremely active and may have selected the females by their color or form or quiescence. On one of these occasions some of the active, light brown males were placed in a cage contaning a few dark males quiescent among some stones. The light colored males in their restless search for females before capture occasionally clasped each other, but never for long. The dark males, however, were relentlessly pursued and clasped so that they had to seek refuge, either by crawling between suitably placed stones or by climbing the walls of the cage.

It seems likely that at night the sexes of *B. regularis* identify each other by sounds, and that the female selects the male with which she will mate. On the much rarer occasions when pairing occurs in daylight the male selects the female and it is possible that he identifies her by her depth of color.

HABITAT.—*B. regularis* can be found anywhere in and around Lagos except in closely built-up areas. They are uncommon near main roads but they have croaked throughout the year in a small patch of marshy ground between Lagos railway station and the main road north from town. The station is a hive of activity during the day and the road carries heavy traffic at all hours except in the early morning.

During the day these toads usually conceal themselves and captured ones may easily be kept during the day by wrapping them in a duster or by placing them in a pile of grass cuttings in the open. Much searching of nooks and crannies at Yaba during the day produced only a few small toads and by exclusion it is concluded that they spend the day in dense undergrowth. A few have been found there but the risk did not justify prolonged searching.

On a few occasions toads have been discarded in dense undergrowth during the day and they have always been found at the same place a few hours later. It seems likely, therefore, that these toads usually spend the day immobile in dense undergrowth.

Soon after dusk these toads are found on open ground. The males divide into two groups. Those without sex marks and a few with sex marks move apparently at random on the open ground; the rest move towards water. The females also divide into two groups, only one of which moves towards water. The males arrive at the water first. At Yaba, for example sunset occurs from about 6:00 to 7:00 PM throughout the year, but it is seldom worth while searching for males before 10:00 PM, at which time most of them are within 150 meters of the lake. The females at this time are almost all more than 150 meters from the lake. It follows, therefore, that by a suitable choice of time and place a majority of males, or a majority of females, or a group of vegetating males and females may be captured, and it also follows that it is scarcely possible to define a random sample of all the toads in a large area.

The above observations were made in dry weather. In very heavy rain the toads shelter whatever the hour, but in lighter rain they become mobile during the day.

Toads were occasionally found in bushes and when escaping did not hesitate to jump into a bush and climb. Seventy-eight males were placed in a cage with walls 1.5 m. high made of 1.25-cm. mesh netting. They climbed slowly to the top of the wall, balanced precariously on the edge, and after wobbling for a time fell off on the outside. They can climb down but rarely do so, though a fall occasionally results in a broken leg.

In Lagos *B. regularis* is popularly considered to burrow into the ground, though I have never observed this. An aquaintance, however, produced a female which he had found 15 cm. below ground level in a flower bed. Also 201 males were put in a cage which had been used for rabbits. After 11 days 42 males had escaped. The earth floor was dug up and an old burrow was found 15 cm. below ground level. This burrow was filled in and no more toads escaped. The 42 males, however, were not recovered.

BREEDING.—The fertilized ova of *B. regularis*, as with other members of the genus *Bufo*, are seen as black spheres freely movable in very regular transparent tubes. Fertilized ova were obtained by placing males and females captured near water, the males with sex marks, in a tank, 120 cm. × 120 cm. × 30 cm. deep, containing water with lilies and *Pistia stratiotes*. The presence of stones made the depth less in places. Amplexus occurred and long tubes of fertilized ova were laid from lily stem to lily stem, but not around the *P. stratiotes*, which floats. Fertilized ova for study were obtained in this way twice. For both experiments the water temperature was 30° C. Free swimming tadpoles developed in both experiments within 24 hours. Metamorphosis began after 143 days in the first experiment and after 122 days in the second, but the two differed. In the first the tadpoles were allowed to remain in the tank, which also contained a colony of *Bulinus*. In the second the tadpoles were transferred after 64 days to a glass tank where they were fed on an excess of small crustaceans and heart muscle.

At metamorphosis the toad climbs on to a leaf or stone at the water's edge, where it sits for 1 to 2 days during which time it does not feed. It then migrates and these toads of 0.5 cm. from snout to vent, unlike the adult, can climb vertical surfaces of wood, cement and unpolished glass. Their subsequent development has not been traced but twice large numbers of small toads, 1.5 cm. from snout to vent, reddish in color and resembling *B. regularis*, have been seen migrating across the Yaba site. Ultimately they have been found, 3.6 cm. from snout to vent but easily identifiable as *B. regularis*, in gardens and farms, always some distance from water.

BREEDING SEASONS.—Breeding in amphibians is commonly seasonal and observations were made to ascertain to what extent the breeding of *B. regularis* around Lagos is seasonal. Climatic tables are available for Lagos (Air Ministry, 1949). In general the climate is hot and humid with an average air temperature varying from 25.5° C. in July and August to 28.5° C. in February, March and April. The main rainy season begins in April

and ends abruptly at the end of July. August is a dry month and is followed by a short rainy season in September and October. The dry season extends from November to March. Rainfall figures for Yaba for October, 1950 to September, 1951 are also available (Barker, in litt.,) and show that the year October, 1950 to September, 1951 was similar to the average year, though a little drier.

The typical croak of the male *B. regularis* was heard on at least one night of each week throughout the year. Also toads were captured in amplexus at least once each month of the year. Using the amount of croaking and the ease of collecting toads near water as rough indices of the amount of breeding, there appeared to be three ill-defined breeding seasons: at the end of April at the beginning of the main rainy season, in July, and in September and October. Between these seasons very few toads might be found near water. By the end of June, 1951, for example, croaking was rarely heard and few toads could be found near water, though they were plentiful on farms and in gardens, the males often without sex marks.

On two occasions during the year the males showed intense activity in searching for females; the actual process of selection has already been described. The first occurred on January 17, 1951 at Yaba at the height of the dry season. Hundreds if not thousands of toads were found in the morning around the lake which had partly filled with 56 mm. of rain during the preceding 48 hours. Very little breeding occurred because females were very scarce. The second occasion was very similar but occurred at Yaba on June 1, 1951, 14 days after the ground had become soft with the main rains. A similar plague of toads was seen at Oshodi but not on January 17 or June 1.

Seetzen's (1855) observations suggest that there is a clearly defined breeding season in Egypt for *B. regularis*, occurring when the Nile has risen just enough to flood the fields. The observations made around Lagos suggest that there are no clearly defined breeding seasons. These findings do not conflict, because the climate of Egypt differs greatly from that of Lagos.

AESTIVATION AND MIGRATION.—*B. regularis* was much more plentiful at Yaba and Oshodi during the rainy seasons than during the long dry season. Either these toads aestivated on these sites or migrated.

At Yaba, during the long dry season, holes were dug in the bed of the lake and many nooks and crannies were searched. No buried toads were found and all of the very few toads found in nooks and crannies were active when extracted. Yet on January 17, 1951, at the height of the dry season, the lake shore teemed with toads. They could not have come from hides in the compound and no holes in the ground could be found from which they might have emerged. Migration, therefore, seems the more likely explanation.

At Oshodi most of the ground had been cleared for cultivation by the end of the long dry season, but during this clearing few toads were found and they were active. Also, when the main rains came, and toads became more plentiful, none was seen emerging from the ground nor were any holes found from which they might have come.

In April, 1953, *B. regularis* was found on the banks of a small stream near Kano, about 700 miles north of Lagos. The climate of Kano approximates more closely that of Egypt than that of Lagos, and these toads had survived several months without rain and with a very low day-time relative humidity.

The lack of evidence of aestivation agrees with the report of Seetzen (1855), but if aestivation does not occur then the toads must migrate. In the Lagos area they may migrate to the marshy, overgrown and inaccessible banks of the streams draining into Lagos Lagoon and into the many creeks to the west of town.

FOOD.—The stomachs and cloacae of more than 50 toads were opened to ascertain what they had eaten. The stomachs of the males captured while croaking contained at most a little insect debris, though not enough were examined to justify the conclusion that this is always so. Others contained partly digested remains of numerous insects and one toad was found with the fallen calyces of *Morinda lucida* in its stomach. The cloaca always contained an amorphous black material.

In captivity *B. regularis* took all flying insects offered, worms, maggots and the calyces referred to. Insects were taken at rest. Worms and maggots were ignored until they

moved. The calyces need not be moved. Some toads will take full grown *Bulinus* from water, and dissections of five toads showed that the shell is digested in 5 days.

SELECTION OF *Bufo regularis* FOR LABORATORY USE.—The observations and experiments recorded in this paper were made in order to secure a homogeneous group of adult male *B. regularis* for laboratory use. It seems reasonable to assume that there is a breeding cycle. The male even when weighing as little as 20 g. becomes capable of breeding and croaks nightly alongside water until amplexus occurs. The pair then enters the water and tubes of fertilized ova are laid. This process has been observed many times but always before noon. What happens next is not known but it is thought that the pair remains in or near water until after dusk, when it moves away from water to feed. After a time the male loses his sex marks and reflexes but later he recovers these. He then nightly moves to water to croak for a female. There appear to be three definite stages of this cycle in the male: the pre-mating stage during which he does not feed but, with full sex marks, croaks nightly close to water for a female; the mating stage lasting about 12 hours; and the post-mating stage during which the sex marks and reflexes disappear, and during which he feeds at a distance from water. The timing of the ill-defined breeding seasons in the Lagos area suggests that the whole cycle occupies not less than about 6 weeks in the male. Males in the mating stage are very difficult to catch and in the post-mating stage are often indistinguishable from females. Hence it is likely that the most homogeneous group may be obtained by searching for croaking males at night near water. If this produces an inadequate supply, a collection of all males with sex marks and reflexes found near water will be a slightly more heterogeneous group because a few males in the post-mating stage will be included. Only a minority of such males will be collected, however, because the supply of females always appears to be quite insufficient for the number of croaking males. The croaking usually continues with little reduction in volume till dawn.

The note on ecology by Seetzen (1855) suggests that there is only one breeding season each year in Egypt; there is no one such season in Lagos. Hence it should be possible to maintain males in the laboratory, by a suitable choice of environment and food, so that an adequate number in the pre-mating stage is always available.

MAINTENANCE IN CAPTIVITY.—Information about the maintenance of toads other than *Xenopus laevis* in the laboratory is very scanty. Gadow (1909) kept large toads for 4 years. He also reported that Boulenger kept a specimen of *Bufo vulgaris* for 12 years in a box provided with sod, a pan of water and plenty of varied food. Stephenson (1947) in the UFAW Handbook barely mentioned the keeping of toads other than *Xenopus laevis*. Since the male amphibian became a pregnancy test animal, however, several workers have reported their methods of maintaining stocks of toads in their laboratories. Galli-Mainini (1948) kept *Bufo arenarum* in basins 1 m. × 60 cm. × 60 cm., one of which was adequate for 300 toads. He maintained them damp, did not feed them and kept them for several months. Haines (1948) also stored *B. arenarum* but used large cages or glass walled tanks, with the floor covered to a depth of 10 cm. with moist peat, mold or sand. A shallow tray of water was put with the toads, which were fed with earthworms, meal worms, cockroaches and other insects. McCallin and Whitehead (1950) stored *Bufo americanus* and *Bufo woodhousei* in wooden boxes with some earth and a pan of water, force feeding with meat every 10 to 14 days. Chhung Hin and Webb (1949) stored *Bufo regularis* in a similar way but force fed thrice weekly. Mohanty and Pabrai (1950) stored *Bufo melanostictus* in a galvanized iron tank with 10 cm. to 15 cm. of water changed daily. This tank had two platforms with steps leading down to the water and an electric lamp was fitted to attract insects. They reported that this tank was successful for the 2 months it was under observation. Sulman and Sulman (1949) stored *Bufo viridis* in a cool place in glass containers containing 2 cm. of water, but few survived more than one month.

Few of these workers have reported the mortality of their toads, though a heavy mortality was probably not a problem to most of them. Only two species, however, *Bufo melanostictus* and *Bufo viridis*, were stored in a

warm climate and both with only moderate success.

For collecting, a stocking is most convenient. Toads will lie in it for several hours without damage. In a small box they jump and damage themselves.

Jumping may be prevented by using boxes of sufficient height. Some *B. regularis*, weighing 50 to 70 g., were placed in lidless, wooden boxes 23 × 35.5 × 46 cm. high. A petri dish of water was placed in each box and a piece of porous brick or concrete, reaching 15 cm. above the floor, to provide a hide and so that the humidity could be maintained by soaking in water in dry weather. Some toads escaped and many damaged themselves by jumping. When the height of the wall was increased from 46 to 61 cm., toads of the same size made no attempt to escape. One of these boxes was adequate for 8 toads. Long, wooden boxes 1 m. × 30 cm. × 30 cm. high were also used but required a lid or the toads climbed out; they did not jump. One of these long boxes was adequate for 30 toads. Once each week these boxes were washed with tap water and dried in the sun. If more toads were stored in them, washing and drying had to be more frequent. Toads kept in these boxes were not fed but lived for months, though with obvious wasting.

For long term storage an out-door cage was used. It had an earth floor of 3.5 sq. m. adjacent to a concrete slope leading to a tank 1 m. × 1.37 m. × 30 cm. deep. The walls were of brick for the first 30 cm. and then of 1.25-cm. mesh wire netting to a height of 2.4 m. above the ground. The top of the cage was also of wire netting. The whole cage was well shaded by a large tree and a piece of corrugated iron gave some protection against torrential rain. A row of rough pieces of brick was laid along the windward wall to provide a hide for the toads. As the toads entered the water at night and as they will take *Bulinus* from water, a colony of these snails was established in the tank on the principles given by Standen (1949). Mosquito larvae were completely controlled by adding D.D.T. every 3 months in the proportion of 1 ml. of a 2 percent solution in ethyl alcohol to 6 l. of water.

MORBIDITY AND MORTALITY IN CAPTIVITY.—Haines (1948) reported that metals and anaesthetics were lethal to *Bufo arenarum*. Many *Bufo regularis* were stored overnight in copper and tinplate boxes without any immediate mortality, but even traces of chloroform and ether were lethal.

If kept in damp surroundings *B. regularis* readily develop ulcers of the limbs and abdomen at the points of contact with the ground. These ulcers usually heal quickly if the toad is placed in a dry box, but the healing of indolent ulcers may be induced by washing under the tap. These ulcers have been found on capture.

More than 700 toads were injected with urine by Crew's method (Crew, 1939) and two of these developed a massive necrosis of the leg muscles on the side of the injection and died. From the necrotic muscles of both these toads a pure culture was obtained of a Gram negative bacillus, coliform in appearance, with spreading colonies. Identification could not be completed but both bacilli probably belonged to the *Proteus* group.

Two hundred and one males of *B. regularis* were put in the out-door cage on January 18, 1951. Forty-two of them escaped as previously described and 139 of the rest were alive on February 12. Thirty active, plump toads were then removed and 79 of those left behind were alive on March 16. The 30 toads removed may reasonably be counted as having survived for one month in the cage, so that the approximate mortality was 13 percent of 159 in the first month and 22 percent of 139 in the second month of captivity.

The stomachs of the toads that remained alive in this cage after two months were examined. The toads that were plump were found to have eaten *Bulinus* while those that were wasted had empty stomachs. Force feeding with three *Bulinus* adults every seven days was then started with apparently good results. No figures for mortality, however, can be given because it was no longer possible to prevent irregular additions and withdrawals from the cage. Certainly wasting seldom occurred after force feeding had been started.

Most of the toads that died in the cage were autopsied but there were no constant findings. Not all were wasted. Some had massive filarial infestations of the coelom and pericardial cavities. A few had an infestation of the liver. In one the liver contained many macroscopic

pale yellow cysts. Microscopical examination showed cavities lined by flattened columnar epithelium, similar to that forming the bile ducts, and containing a worm, presumably a fluke of some sort. Usually no cause of death could be determined.

Since toads are poikilothermic, the cloacal temperature of individuals resting in the shade may be expected to be between the dry bulb and wet bulb temperatures. This was confirmed for *B. regularis*. Ten active, plump toads that were dry and that had been resting in a box were examined. The cloacal temperature varied from 27.8° C. to 30.3° C. with a mean of 28.9° C. The dry bulb temperature was 32.2° C. and the wet bulb 26.4° C.

The first 25 individuals of *B. regularis* captured in October, 1951 were placed with a dish of water in one of the long boxes previously described. The box was placed in a room that became very warm during each afternoon, because the sun shone into it. Twenty-one of these toads died in 27 days. The box was then moved to the next room, which was cooler, and the mortality became negligible. No cause of death could be found on autopsy of the 21 toads. At the same time some toads in the second, cooler room escaped (experiments were being made with boxes of different sizes) and made their way into the first room, where they were always later found in the litter in the rabbit cages there. These toads also died but only after they had shrunk considerably. They became thin and wasted and just before death could scarcely move, but even at this late stage they could be completely revived by placing in tap water for an hour.

It seems likely that these escaped toads were only dehydrated, but dehydration cannot have been the cause of death of the 21 that had been kept in the warm room because they did not shrink and waste. The mortality fell, however, when toads were kept in the same box in a cooler room, and it seems likely that the 21 died from effects of heat other than dehydration.

With this possibility in mind it is of interest that all the 21 toads died during the night, that almost all the deaths in the out-door cage occurred at night, that during the day these toads remain immobile in dense undergrowth, the place where the lowest dry bulb temperature is found, and that they become mobile during the day only if it rains, which always implies a fall in the dry bulb temperature.

Sixteen toads were divided at random into two groups of eight. The groups were placed in identical ventilated boxes with a dish of water. One box was placed in a hot room, dry bulb 37.8° C. and wet bulb 34.2° C., for 3¼ hours. The other was placed in a cool part of the laboratory. The wet-bulb temperature in the hot room was higher than the dry-bulb temperature in the cool part of the laboratory, so that it may be assumed that the body temperatures of the toads in the hot room rose. The toads in the hot room became more active than those elsewhere but there were no deaths in either group during the period of observation, which ended 24 hours after the toads were placed in the hot room. This was a crude experiment but it suggests that if the effects of heat other than dehydration cause death, they must be exerted over several days.

Summary

Observations are recorded on the identification and ecology of *Bufo regularis* (Reuss), made to facilitate the selection and maintenance of the male of this species for use for pregnancy diagnosis. These observations were made at many sites near Lagos, Nigeria, during a period of 12 months.

The identification key given by Boulenger (1880) is adequate for identifying the adult male and female of the type. Neither varietas A nor varietas B could be identified and it is doubtful if either occurs in or near Lagos. It is likely that only var. A occurs in Mauritius.

It is not always possible to select males or females from their reactions and external appearances. The throat color is an unreliable index of sex, but the amplexus reflex, croaking and nuptial pads have never been found in the female. Identification of sex for mating under natural conditions appears to depend on the croak of the male and a signal from the female, except for very rare occasions when the male appears to identify the female by the depth of color of her dorsal surface.

No clearly defined breeding seasons were observed. Instead there appeared to be a breeding cycle which occupied not less than about six weeks in the male.

No evidence of aestivation was found.

The movements of *B. regularis* during a period of 24 hours under different weather conditions are described.

The methods of maintaining species of the genus *Bufo* in captivity are briefly reviewed and the methods used in Lagos, boxes and an out-door cage, are described in detail. The toads in the cage were force fed weekly with *Bulinus* cultured in a tank in the cage.

The causes of ill-health in the toads maintained in this way are briefly reported, in particular the effects of heat other than dehydration.

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Herpetological Notes

SOME RECORDS OF REPTILES OF GEORGIA.—I am grateful to Charles Durant, James Knepton, Charles Lowe, Owen Riley, and Herschel Webb for their aid in collecting specimens and to Robert L. Humphries and Albert Schwartz, Charleston Museum, for loan of the milksnakes in their collections.

Eumeces anthracinus Baird.—The coalskink is uncommon in the southern part of the Appalachian Mountains where the two races, *E. a. pluvialis* and *E. a. anthracinus* probably intergrade (Smith and Smith, 1952, Univ. Kansas Sci. Bull., 34: 679–94). For Georgia a single specimen has been recorded (McCauley, 1940, COPEIA, (1): 50). This specimen taken at Mountain City, Rabun County, unfortunately cannot now be located. Thus the six specimens recently collected in northern Georgia are of special interest.

Five of the specimens are juveniles (Table I). They were taken near the junction of Fannin, Union, and Lumpkin counties near mountain streams, the one farthest away being about 20 feet from water. They all have seven supralabials with dark pigment along their sutures, more on the posterior ones than on the anterior, but with the light-colored central area of each usually not bordered ventrally by black. In all, the body is black, the tail bluish violet, and there are light red markings on the chin and sides of the head. Smith and Smith (1952, *op. cit.*) indicated that Burt (1928, Trans. Acad. Sci. St. Louis, 26 (1): 1–81) and Gloyd (1928, Trans. Kansas Acad. Sci., 31: 115–41) may have over-emphasized the black body color of juveniles; I disagree. In the Georgia specimens it is plain black—coal black as implied by the common name. Furthermore, none possess a distinctive linear pattern as de-

TABLE I

CHARACTERISTICS OF FIVE JUVENILES OF *Eumeces anthracinus*

Specimens taken July 15 and 29 are from Lumpkin Co., 2 mi. S of Winding Stair Gap, at 2,050 ft.; those taken August 5 are from Union Co., near junction of Edmundson Branch and Rock Creek, at 2,550 ft.

Date, 1953	Scale rows at midbody	Length (mm.)		Stripes
		Snout-vent	Total	
July 15	28	24.8	58.8	Very faint, eye to midbody, and ear to forelimb.
July 29	28	30.8	86.3	Faint, eye to midbody, and ear to forelimb.
	27	31.0	83.8	
Aug. 5	27	20.4	Tail broken	Faint, eye to near forelimb.
	28	24.2	55.9	None evident.

scribed by Dowling (1950, COPEIA, (3): 235) for a juvenile taken in Alabama.

It is evident that coalskinks in northern Georgia hatch in July and early August with a snout–vent measurement of about 20 mm. The umbilical scar is present in the smallest specimen (snout–vent, 20.4 mm.). Apparently the tail grows faster than the rest of the body. The tail makes up about 57–58 percent of the total length at the time of hatching and about 63–64 percent when a snout–vent measurement of about 30 mm. is reached. This more rapid growth of the tail is in accordance with what one would expect because of the role of that structure in survival of the individual through tail autotomy.

On the basis of the number of scales at midbody (average 27.6), the presence of 7 supralabials with black along their sutures, the absence of stripes or the presence of inconspicuous ones on the bodies of juveniles, these specimens are best assigned to *E. a. pluvialis*.

An adult male, taken about 50 miles to the northeast at an elevation of about 3,000 ft. on Chestnut Mountain, Rabun County, March 27, 1954, differs from the juveniles. It measures 50 and 123 mm. in snout–vent and total length, respectively. On the right side it has seven supralabials, but only six on the left. There are only 25 scale rows at midbody. There is no evidence of spotting on the supralabials; a continuous light stripe is present through the posterior ones. This stripe continues through the ear opening above the axilla to the groin where it divides into an indistinct segment on the anterior part of the thigh and another extending to the base of the tail. On the side there is a dark brown band that extends from the eye to the base of the tail. The tail is grayish brown, except for its regenerated tip. Above this lateral dark brown band there is a dorsolateral light stripe from the eye to the tail. A row of brownish black spots separate this stripe from the dorsum which is grayish brown with a middorsal brown area from head to base of tail. The venter is gray, except the chin and throat which are pinkish red. This reddish pigment is also found on the snout and on the sides of the head and neck. A lighter red color is present in the axilla and on the anterior one-third of the side of the body. Taylor (1936, Univ. Kansas Sci. Bull., 23: 1–643) has described a similar reddish coloration for males of *E. s. septentrionalis* during the breeding season. It is difficult to assign this specimen to either of the two known races, for indeed it possesses characteristcis of both. Accordingly it is considered an intergrade.

Diadophis punctatus edwardsi Merrem.—Blanchard (1942, Bull. Chicago Acad. Sci., 7(1): 1–144) stated that the southern extremity of the Appalachian Highlands should be explored for *D. p. edwardsi*. Twenty-four specimens were taken in northern Georgia from Rabun, Union, Fannin, Murray, White and Lumpkin counties. Twenty of these specimens have unspotted chins, the others generally have one or two tiny spots on the first or second lower labial scales. Four of the specimens have the entire venter unspotted, the others have a median row of small, black spots on the belly. Those with venter unspotted, the typical pattern for *edwardsi*, are all from the higher parts of Rabun County and are unequivocally of this subspecies. Moreover, the presence of ventral markings does not necessarily exclude specimens from being considered as *edwardsi*. Blanchard (1942, *op. cit.*) acknowledged that ventral spotting is common in some parts of the range, e.g., western North Carolina. The structural characteristics of these specimens from northern Georgia indicate that they are best assigned to *edwardsi*. The large number of ventrals and caudals (over 200) and the high ratio of caudals to ventrals provide the most convincing criteria. It should be noted that ventrals were counted in the usual fashion and not by the method outlined by Dowling (1951, British Jour. Herp., 1(5): 1–2). This was done so that a more direct comparison could be made with Blanchard's data (Table II).

Ringneck snakes from the northeastern part of the Piedmont Region (Clarke County) are obviously intergrades between *D. p. edwardsi* and *D. p. punctatus*. They are intermediate in total number of caudals and ventrals, in total length, and in ventral markings. Ten of the 12 specimens lack chin markings altogether. In general, specimens from the southern and western parts of the Piedmont (Harris, Morgan, Greene, and Wilkes counties) show strong affinities to *p. punctatus*. Nevertheless, there are some indications of *p. edwardsi*. Specimens from the southern part of the state (Grady and Thomas counties) possess markings and scutellation more

TABLE II

SOME STRUCTURAL CHARACTERISTICS OF RINGNECK SNAKES FROM GEORGIA

V = ventrals; C = caudals; asterisk indicates data taken from Blanchard

Locality	Number of spec., and sex	Ventrals		Caudals		Ventrals plus caudals		C/V ratio		Max. length (mm.)
		Range	Av.	Range	Av.	Range	Av.	Range	Av.	
*edwardsi**	910 ♀	146–176	160	41–61	51	190–228	211	...	32	517
	♂	139–162	151	48–65	57		208	...	38	...
Ga. Mts.	10 ♀	150–162	158	50–54	52	201–217	210	32–34	33	449
	14 ♂	144–157	151	55–63	58		209	37–41	39	...
Clarke Co.	7 ♀	137–152	148	46–50	47	184–200	195	30–34	32	408
	6 ♂	137–143	140	51–61	57		197	37–44	40	...
Cobb Co.	2 ♀	149–153	151	39–43	41	188–196	192	26–28	..	395
Morgan, Greene, Wilkes counties	4 ♀	142–150	145	41–43	42	183–193	187	29–30	29	283
	1 ♂	137	...	51	..		188	37	..	...
Harris Co.	1 ♀	151	...	41	..	192	...	27	..	...
Grady, Thomas counties	2 ♀	140–141	...	38–41	..	179–192	180	27–29	..	263
	2 ♂	137–143	...	49–50	..		189	34–36	..	...
*punctatus**	115 ♀	134–155	144	34–50	41	–190	185	...	28	...
	♂	127–150	137	43–56	47		184	...	34	367

typical of *p. punctatus*. Additional specimens are needed before the exact limits of the zone of intergradation can be known.

I have noted that the sex of ringneck snakes can be reliably ascertained by the ratio of caudals to ventrals. In no instance has overlapping of these ratios occurred in animals from the same general locality. Accordingly this method is better than that of the tail-to-total-length ratio which results in some overlap. Furthermore the ratio of caudals to ventrals is diagnostic of the two forms discussed. Typical *p. edwardsi* (including those from the mountains of Georgia) and those from Clarke County have ratios which average about 32 and 38 percent for the females and males, respectively. All other specimens from Georgia and those reported by Blanchard as *p. punctatus* have ratios of about 28 for the females and 34 for the males.

Haldea valeriae valeriae Baird and Girard.—In the checklist of North American amphibians and reptiles (Schmidt, 1953) the eastern groundsnake is recorded as ranging as far south as Tennessee and North Carolina. Actually this species ranges throughout most of Georgia as reported earlier by Schmidt and Davis (1941, Fieldbook of snakes: viii + 365). This is indicated by the fact that 17 specimens have been taken in the following counties: Grady, Floyd, Morgan, Greene, Oglethorpe, Murray, Lumpkin, Union, and Rabun. All specimens were taken from under rocks or boards. The largest specimen, a female, measured 217 mm. from snout to vent and 251 mm. in total length. A specimen taken in Rabun County gave birth to four young on August 16, 1953, and 6 days later to three more offspring. Of these young the largest was 91, 106 mm., the smallest 78, 94 mm., snout-vent and total length, respectively. Their average measurements were 81, 98 mm.

Lampropeltis doliata triangulum Lacépède.—Conant (1943, Proc. New England Zool. Club, 22: 3–24) greatly clarified the status of the eastern milksnakes and wisely disposed of records of *d. triangulum* supposedly taken from Augusta, Georgia, the Piedmont and Coastal Plain of South Carolina, and from Florida. Actually, there are no authenticated records in the literature of this animal from Georgia. In the last 2 years, six specimens have been taken. Four of these were under stones at elevations of 3,600 to 4,700 ft., on the very tops of some of the highest parts of the State: Brasstown Bald, Union County; Hawk Mountain, Fannin County; and Springer Mountain, Lumpkin County. The other two specimens, collected east of Margret near the border of Fannin and Union counties, were at a much

TABLE III

SOME CHARACTERISTICS OF MILKSNAKES TAKEN IN GEORGIA

UG = University of Georgia; CM = Charleston Museum; RLH = Robert L. Humphries; an asterisk denotes that the tip of the tail is missing

Character	UG 304	UG 167	UG 59	CM 53. 154.9	RLH 239	RLH 231
Sex	♀	♀	♀	♀	♂	♀
Snout-vent (mm.)	348	194	767	185	655	296
Total length (mm.)	381*	223	840*	214	746	344
Dorsal blotches (head-vent)	27	34	28	36	32	34
Lateral blotches with red centers	Few	None	None	Many	Many	Few
Ventrals	209	198	208	199	204	...
Caudals	...	47	...	48	40	47
Upper labials	6-6	7-7	6-7	7-7	7-7	6-7
Lower labials	9-8	9-9	9-9	9-9	9-9	8-8
Anterior temporals	1-2	2-2	1-2	2-2	2-2	2-2

lower elevation, between 2,100 and 2,200 ft. Thus, in Georgia the milksnake appears to occur chiefly in the higher mountains in the northern and northeastern parts of the state; however, occasional individuals are found at low elevations in the valleys of that area.

The specimens from Georgia (Table III) are intermediate in some respects between *d. triangulum* and *d. triangulum* × *d. temporalis* intergrades as described by Conant (1943). By having a large number of ventrals, an average of 204.6 as compared to 197.7 for *d. triangulum* and 192.6 for intergrades, they more closely approximate typical *d. triangulum*. The average caudal count (45.5) is also higher than that of *d. triangulum* (43.6) and the intergrades (43.0). Upper labials number 7 in *d. triangulum*, 6 (33 percent) and 7 (67 percent) in the Georgia specimens and 6 (2.5 percent), 7 (95 percent) and 8 (2.5 percent) in the intergrades. However, there is much variation in markings. This is especially true of the head-neck marking which is Y-shaped in two, irregular in three, and circular in one. They are irregular or circular in the intergrades and usually Y- or V-shaped in *d. triangulum*. The middorsal blotches are large and on the average their red pigment reaches the second or third scale row. From head to vent the dorsal markings average 31.8 whereas Conant reported an average of 36.6 for *d. triangulum* and 28.0 for intergrades. In *d. triangulum* two rows of spots are reported; there is only one row in the Georgia specimens and most of them lack red centers. The ventral surfaces of the specimens are heavily marked. In three they are checkered as in *d. triangulum*; in the other three the black markings are confluent over most of the venter as in some of the intergrades. Thus with regard to their markings the Georgia specimens seem to be intergrades. However, Conant pointed out that "Even in the midst of the range of *triangulum*, in areas remote from contamination by *temporalis*, variation in individual specimens may be quite noticeable, particularly in regard to head markings. While the bulk of the population may be normal, some snakes may have the "Y" or "V" distorted or broken, and the markings of the head may show a considerable departure from the normal." Conant further stated that, "Because of the great amount of individual variation it is impossible to draw any hard and fast line between *triangulum* and *triangulum-temporalis* intergrades." On the basis of the above information I think that the Georgia specimens are best classified as *d. triangulum*.—BERNARD MARTOF, *Department of Zoology, University of Georgia, Athens, Georgia.*

HISTOLOGICAL EVIDENCE OF SAURIAN PHYLOGENY.—During the course of a comparative study of the adrenal glands of certain common representatives of the various orders of reptiles it was observed that considerable variation occurs in the disposition of the cortical or interrenal cells of the saurians covered by this study. Moreover, when the various species of lizards are arranged into groups on the basis of the disposition and morphology of the cortical cells, it is found that they fall into three general categories having similar histological features. For the sake of convenience these are designated as the gekkonid, anguimorphid and iguanid types.

The characteristic histological feature of the gekkonid type of adrenal is the radial arrangement of tall wedge-shaped columnar cells into cords having a consistent disposition of the nuclei at their periphery. This arrangement is found in the four species of the Gekkonidae that were examined, namely: *Tarantola mauritanica*, *Gonatodes fuscus*, *Sphaerodactylus cinereous*, and *Hemidactylus turcicus*. A similar striking polarity and arrangement of the cortical cells has already been described in the Xantusidae by Miller (1952, Anat. Rec., 113: 309–23). In addition, the following members of the Scincidae—*Eumeces fasciatus*, *E. obsoletus*, and *Lygosoma laterale*—exhibit this same pattern. A single specimen of the Dibamidae, *Dibamus novaeguineae*, and two representatives of the Pygopodidae, *Lialis burtoni* and *Pygopus lepidopus*, were examined histologically and found to have a gekkonid arrangement of the cortical cells.

The teiid lizard, *Cnemidophorus tessellatus*, exhibits a more or less random dispersion of the cortical cells, with only occasional cords showing a radial arrangement of polarized cells which have their nuclei aligned at the periphery. This arrangement is similar to that described for the Lacertidae

by Braun (1882, Arb. a. d. Zool. Zoot. Inst. Wurzburg, 5: 1–30).

The anguimorphid adrenal cellular pattern consists of an irregular arrangement of polyhedral low columnar cells which exhibit no tendency to form cords consisting of regularly arranged tiers. This arrangement was found in the glasssnake, *Ophisaurus ventralis*, and the alligator lizard, *Gerrhonotus coeruleus*, in the course of the present investigation. Retzlaff (1949, Anat. Rec., 105: 19–34) also demonstrated this irregular disposition of cortical cells in the latter species. Hartman and Brownell (1949, The Adrenal Gland) described a similar pattern in the anguimorphid lizard, *Heloderma suspectum*.

The disposition and morphology of the adrenal cortical cells in the Iguania is somewhat variable, even within family groups. All the species examined in the current work, or those previously described, appear to have a more or less regular arrangement of the cells into cords. In the agamid lizard, *Uromastix hardwicki*, Vincent (1896, Proc. Birmingham Nat. Hist. and Phil. Soc., 10: 1–26) described the cortical tissue as being composed of cords consisting of a double row of tall columnar cells, each having a centrally placed nucleus. Minervini (1904, Jour. de l'anat. et del al physiol., 40: 449–92) reported that the cortical cells of the chameleon, *Chamaeleon* sp., are small and polyhedral, with centrally located nuclei.

In the Iguanidae, the cortical cells of *Anolis carolinensis* and *Sceloporus undulatus* fit the general description of those of the chameleon. Their adrenal cells are arranged in cords consisting of low columnar cells in regular rows, with their nuclei centrally located. On the other hand, the cortical cells of the horned lizard, *Phrynosoma cornutum*, are more columnar, with the nuclei somewhat peripheral in position.

According to Camp (1923, Bull. Amer. Mus. Nat. Hist., 48: 289–481) the Gekkonidae represent the most primitive family of lizards, with the Xantusidae being intermediate between the Gekkonidae and the Scincidae. The Lacertidae are considered to be an early offshoot from the Scincidae and the Teiidae to be a branch of the Lacertidae. The Anguimorpha, which includes the Anguidae and Helodermatidae, are believed to have separated from the primitive Gekkota very early in the Mesozoic Era. The Iguania, which includes the Iguanidae, Agamidae, and Chamaeleontidae, are considered as a natural group that has been separated from the primitive Gekkota since Triassic times.

Since, as Camp (*op. cit.*) pointed out, the Gekkonidae represent the most primitive group, it seems appropriate to assume that the gekkonid-type adrenal (found in the Gekkonidae) represents a more primitive morphological condition. This type is present also in the closely related groups, the Xantusidae, Dibamidae, Scincidae, and further appears to be characteristic of the species of Pygopodidae that were examined. The relationship of the Pygopodidae presents a taxonomic puzzle because of their morphological peculiarities. Camp places this group among the Anguimorpha. Certain morphological features, however, suggest an affinity with the Gekkonidae. The disposition of the adrenal cells in the pygopodids, *Lialis* and *Pygopus*, is strikingly similar to that of the geckos and unlike that of the anguids.

The Lacertidae and Teiidae exhibit only a slight resemblance to the gekkonid pattern, tending to be somewhat similar to the iguanid pattern, which suggests an early divergence of these families from the Gekkota.

It appears that the Iguania may have diverged early from the gekkonid pattern, since they show only an occasional similarity, i. e., in the horned lizard, *Phrynosoma cornutum*. Furthermore, the Anguimorpha (Anguidae and Helodermatidae) show little resemblance to the gekkonid or iguanid types, thus suggesting that in their long period of separation they have either undergone considerable modification from the primitive gekkonid pattern or have been derived from a primitive stem type differing entirely from the primitive Gekkota.

These histological observations provide further evidence of the evolutionary divergence of the Sauria along several principal lines of descent, namely, the gekkonids (Gekkota and Scincomorpha of Camp's classification), iguanids, and anguimorphids. The gekkonids include the Gekkonidae, Xantusidae, Dibamidae, Pygopodidae and the Scincidae. The Lacertidae and Teiidae show a slight affinity with this group; however, at the present time too few species have been examined to warrant any conclusions regarding the relationship of these families. The iguanids include the Agamidae, Chamaeleontidae and Iguanidae. The anguimorphids include the Anguidae and the Helodermatidae. Any conclusions regarding the phylogenetic relationships of the Sauria as depicted by adrenal histology must await the completion of further studies especially of such important families as the Varanidae, Amphisbaenidae and Zonuridae.

These morphological trends in the saurian adrenal seem to disclose natural affinities of the lizards at the family or superfamily level. Since adrenal morphology is apparently subject to lesser adaptive modifications than the skeleton and musculature, it provides a clue as to the relationships of those groups, such as the Pygopodidae, that have undergone considerable modification. Complete histological and cytological descriptions of the species examined in this study, together with those of representative species of the Crocodilia, Chelonia, and Serpentes, will be published in the near future.

The authors wish to acknowledge their gratitude to Dr. James A. Oliver, New York Zoological Gardens, and to Charles M. Bogert, American Museum of Natural History, for their suggestions and cooperation in lending specimens for this study.—WILLIAM B. HEBARD AND HARRY A. CHARIPPER, *Department of Biology, Graduate School of Arts and Science, New York University, New York 3, New York.*

COURTSHIP BEHAVIOR IN JUVENILE TURTLES.—The courtship of some turtles (*Pseudemys, Chrysemys, Graptemys*) includes a phase in which the male places his fore feet together and vibrates the elongated claws about the female's head. The sex drive is intense; a male may court a female and continue attempts to copulate for periods of several days. This part of the courtship pattern has been reported by a number of observers but the complete sequence of events from initiation of courtship to copulation has not been described. The difficulties of copulation posed by the configuration of the shell and reproductive organs may be related to a need for prolonged "appetitive" behavior. The psycho-biological nature of the courtship remains unknown. Studies of this complex and variable phase of the behavior, not the stereotyped, mechanical act of copulation, promises to provide knowledge of value in understanding relationships amongst emydid turtles.

The assumption has been made generally that the initiation of courtship behavior is correlated with the maturation of the testes and the presence of mature spermatozoa in the vas deferens. It has been assumed that courtship indicates sexual maturity. There is no information on the ontogenetic development of courtship behavior in reptiles.

Courtship behavior was observed in hatchling turtles of *Graptemys flavimaculata* Cagle, *Graptemys kohni* (Baur), *Pseudemys floridana suwanniensis* Carr, and *Pseudemys scripta elegans* Wied between August 23 and October 2, 1953. These hatchlings, with the exception of *G. flavimaculata*, were obtained by laboratory incubation of eggs removed by dissection. The *G. flavimaculata* was collected from the Chickasawhay River, Mississippi, June 21, 1953. No such behavior was observed in 32 other hatchlings of various species maintained under the same conditions. No turtles were sacrificed to determine sex as they were essential to a growth study in progress.

The turtles had been retained in separate containers after hatching. Titillation was first observed when *P. s. elegans* and *G. kohni* were placed in a tank with other turtles. Both individuals were observed, at different times, to approach other emydid turtles, with the fore feet together while vibrating the claws. The pattern was not observed after the first day the turtles were mixed together although they were retained under similar conditions.

G. flavimaculata was observed "courting" a much larger juvenile female on three different occasions during August. Although this turtle was in its first season of growth, it retained many hatchling characteristics. The behavior was not prolonged and consistent as in the mature male.

Possibly the most illuminating observation occurred on October 2 when food was first presented to a hatchling *P. f. suwanniensis*. This turtle was hatched on August 28 from an egg removed by dissection from a female collected on June 7 in the Wacissa River, Florida. It had been isolated and not fed. When a small snail was placed in the aquarium, the turtle immediately approached the snail and vibrated the nails close to it. This was repeated several times before the turtle ate the snail. The same behavior was repeated with two other snails offered on two consecutive days. Subsequent presentation of food or other turtles did not again stimulate this procedure.

This behavior in hatchling turtles demonstrates that the reaction may be induced in the absence of mature gonads or the possibility of attaining the assumed goal of the drive. The behavioral mechanism is present at hatching but probably normally functions only under the stimulus of sex hormones. Such tentative sexual behavior is well known in juvenile mammals but has not been recognized in turtles heretofore.

This specific behavior may have a multiple use to the organism. In each observation the subject was responding to either a strange turtle or an object it had not previously observed. Tentative titillation may be a signal useful in interindividual association or a "testing procedure" to aid in identification of a strange object.—FRED R. CAGLE, *Department of Zoology, Tulane University, New Orleans, Louisiana.*

GENERIC STATUS OF THE AQUATIC SNAKE *THAMNOPHIS ANGUSTIROSTRIS*.—A study of the habits, habitus, color pattern, and structural features of *Thamnophis angustirostris* (= *rufipunctatus* auct., e.g., Smith and Taylor, 1945, U. S. Nat. Mus. Bull., 187: 165) leaves no reasonable doubt that this species is a member of the genus *Natrix*. It is concluded from the data presented below that *T. angustirostris* is more properly recognized as *Natrix angustirostris* Kennicott (*comb. nov.*). This species shares no significant known structural nor behavioral characteristics with the members of *Thamnophis*, but rather, all of them with *Natrix*.

Apparently the only diagnostic character that has formerly and arbitrarily placed *angustirostris* in *Thamnophis* has been the actually variable one supposedly necessitating the designation of gartersnakes (*Thamnophis*) on the one hand as distinct

from water snakes (*Natrix*) on the other, viz., the single or divided anal plate, respectively. This is a useful "key character" and it should be recognized that it (1) is nothing more, (2) is not necessarily consistent within a species, (3) is not, and cannot be, the basis for the concepts of *Natrix* and *Thamnophis*, and (4) is not a so-called "generic character." It is to be emphasized that taxonomic characters that prove generic distinctness do not exist (Mayr, Linsley and Usinger, Methods and principles of systematic zoology: 1–328). The nature of the anal plate has served as the best single external character to distinguish more objectively between two natural evolutionary groups (*Natrix* and *Thamnophis*) as perceived and properly maintained on the basis of the similarities of the species within each, as evinced by their totality of similar characteristics.

Natrix and *Thamnophis* are not widely divergent in the morphological attributes of all of the species encompassed. While there is no question for most as to their proper group allocation, certain ones remain in question; *angustirostris* is one of these. The problem results in part because, in my opinion, *Natrix* and *Thamnophis* are little more than subgenera; the two groups have resulted from successful use of two more or less distinctive yet not completely divergent ecological opportunities.

T. angustirostris is a Mexican snake by distribution. In the northern and disjunctive part of the range of this species, in the Colorado River Basin of Arizona and closely adjacent western New Mexico, what is apparently the last substantial population of this area occurs in Oak Creek, in Yavapai County, Arizona. In 14 available specimens (adult and juvenile) collected over several years in Oak Creek, and preserved in the collections of W. H. Woodin III, Tucson, F. A. Shannon, Wickenburg, and the author, the anal plate is divided in six, entire in six and grooved in two. These data demonstrate that the condition of the anal plate in this species is a meaningless criterion so far as generic relationship is concerned. Tanner (1950, Herpetologica, 6: 194–6) recorded similar data on the variable condition of the anal plate in *Thamnophis elegans vagrans* Baird and Girard; and this situation is not only confined to *Thamnophis* and *Natrix*.

Since the variable condition of the anal plate is valueless as a criterion for the generic allocation of this species, there remains for consideration other characteristics of *angustirostris*. Characteristics of structure, color pattern, behavior, and ecology are considered below.

Cope (1883, Amer. Nat., 17: 1300) was the first to point out that this snake is not a gartersnake, stating that it is "related to *Tropidonotus* [= *Natrix*]." He said, "In its characters it is quite unique, combing the entire anal plate of *Eutaenia* [= *Thamnophis*] with the dental characters of *Regina* B. & G., and a third internasal plate, a character rarely met in serpents. The only North American snake to which it bears any resemblance is *Tropidonotus* [= *Natrix*] *taxispilotus* Holbr. It is a good swimmer, and is doubtless piscivorous, like other water snakes." However, Cope (1900, Ann. Rep. U. S. Nat. Mus. (1898): 1087–90) later placed both his *multimaculatus* and *rufopunctatum* with the gartersnakes, emphasizing the condition of the anal plate. Boulenger (1893, Catalogue of snakes. Vol. 1, p. 214) placed both with the watersnakes, with which there is obviously greater affinity, as originally pointed out by Cope (1900, *loc. cit.*). Ruthven (1908, U. S. Nat. Mus. Bull., 61: 120) followed others in placing this snake in the genus *Thamnophis*, but remarked that "In appearance it is one of the most peculiar forms in the genus."

The habitus of *angustirostris* is unlike typical *Thamnophis* and exhibits certain adaptive peculiarities. The head is especially narrowed, with an unusually high and narrow snout. The nostrils are as in the more aquatic *Natrix*, relatively more dorsad than in species of *Thamnophis*. As in *Natrix*, the internasals tend to be more narrowed. The integument is distinctly rough-scaled, with the scales strongly keeled; apical pits or pores are absent. The ground color is brown; spots are present or absent; distinct longitudinal stripes characteristic of *Thamnophis* are lacking.

The behavior and ecology are distinctly that of *Natrix*. Cope (1900, *op. cit.*: 1089) was the first to remark on its watersnake-like reaction of diving. It very rarely leaves the water and is often found resting on the bottom for long periods. To escape, when at the surface of the water, it dives to the bottom and hides under a rock or other cover. In Arizona and New Mexico it has not been found away from permanent surface water containing fish, upon which it feeds. This species epitomizes the following characterization of watersnakes by Schmidt and Davis (1941, Fieldbook of snakes: 206): "It is evident that our water snakes are adapted to life in the water primarily by adjustments of behavior and physiology. Most obvious of these adjustments are the taking of refuge in the water when alarmed, with voluntary submergence, the accompanying association with permanent bodies of water, and the development of corresponding food habits."

Assignment of *angustirostris* to *Thamnophis* is not consistent with the proposition that members of a genus are more closely related to one another than they are to any other species. The structure, appearance, and habits of *T. angustirostris* are shared, collectively, more with *Natrix* than with *Thamnophis*. The totality of characteristics indicate that this species is so much closer to *Natrix* than to *Thamnophis* that it should be known as *Natrix angustirostris* Kennicott (*comb. nov.*).

Consideration of *angustirostris* as a *Natrix* inhabiting our Far West, erases another biogeographic anomaly. *Natrix* does occur in both Europe and far western North America.

A detailed study of the morphology of the species of *Natrix*, *Thamnophis*, and their close relatives remains much needed, for, at present, there is no known structural character that is unequivocably diagnostic. A character as variable as the anal scale in these groups cannot be accepted as diagnostic. Nevertheless, there is also no question that *Thamnophis* and *Natrix* represent two natural groups.—CHARLES H. LOWE, JR., *Department of Zoology, University of Arizona, Tucson, Arizona.*

NEOTENIC SALAMANDERS, *AMBYSTOMA TIGRINUM*, IN THE ELK MOUNTAINS OF COLORADO.—Although paedogenesis is known in several subspecies of *Ambystoma tigrinum*, it has been suspected in *A. t. nebulosum* (Dunn, 1940, COPEIA, (3): 154–62; Stebbins, 1951, Amphibians of western North America: 47). Osborn (1901, Amer. Nat., 35 (419): 887–904) reported larval salamanders collected by T. G. Lee in 1896, "25 miles from Crede" (sic) in southern Colorado. These specimens ranged from 89 to 262 mm. in total length, and on dissection he found that some were mature. Woodbury (1952, Herpetologica, 8: 42–50) also indicated that larvae of this subspecies may become sexually mature in high mountain lakes of Utah. In a survey of the reptiles and amphibians of the Elk Mountains of Colorado, Blair (1951, COPEIA, (3): 239–40) found *A. t. nebulosum* common in the East River Valley up to an altitude of 10,000 feet. The larvae measured 40 to 130 mm. and the gonads of all were immature on August 3. He reported that there is no evidence of neoteny in the tiger salamander in the area.

While we were at the Rocky Mountain Biological Laboratory near Crested Butte in the Elk mountains in the summer of 1954, Prof. W. H. Emig called our attention to some interesting small lakes on Galena Mountain in White River National Forest. These lakes, which we visited on July 28, 1954, are in a mining area marked "Mexican Cut" on topographic maps and are at an elevation of 11,200 feet, just below timberline. The mud bottoms of these clear lakes are covered with quillwort (*Isoetes* sp.). No fish were seen in the lakes, but insects were abundant. The water was not cold. Salamander larvae were present in large numbers; the smaller ones were close to the shore and could be easily caught by hand, the larger ones were usually in deeper water and when near shore were quite wary. We saw many large ones, but the largest we succeeded in collecting is about 193 mm. long (preserved). No transformed adults were seen, but all the larger larvae proved mature on dissection.

Burger (1950, Jour. Tennessee Acad. Sci., 25: 252–7) reported that *Ambystoma t. nebulosum* was once in Emerald Lake (10,448 ft.) at the head of the East River Valley and it was said to be neotenic. However, the salamanders disappeared when the lakes were stocked with trout in 1928. If this is true, one might surmise that the trout conflict with the neotenic salamanders but not with those that metamorphose, in as much as Blair reports the presence of both trout and larvae in some lakes at lower altitudes. We wish to thank Dr. K. P. Schmidt for helping with references.—HERBERT W. LEVI AND LORNA R. LEVI, *Department of Zoology, University of Wisconsin, Madison, Wisconsin.*

THE SALAMANDER *EURYCEA LONGICAUDA PERNIX* IN KENTUCKY.—Mittelman (1942, Proc. New England Zool. Club, 21: 101–5), in his description of *Eurycea longicauda pernix*, the midland long-tailed salamander, remarked that the subspecies probably occurs in western Kentucky, and mentioned that specimens from Edmonson County seem referable to *pernix*. Schmidt (1953, Checklist of North American Amphibians and Reptiles) listed Kentucky within the range of *pernix*.

Because of the absence of definite locality records from Kentucky, the existence of *Eurycea longicauda pernix* in this state is hereby made a matter of record. All the specimens listed below are in the zoological collections of the University of Kentucky. Acknowledgement is due the University of Kentucky Research Fund Committee for travel expenses incident to the collection of many of these specimens.

Logan County: (1) April 9, 1953, Wolf Lick Hollow, one mile west of Lewisburg. **Muhlenberg County:** (1), April 8, 1954, shore of Green River near the bridge on U. S. Highway No. 62. This specimen is colored laterally as typical *pernix*, but has many fewer dorsal spots. **Pulaski County:** (11), May 27, 1942 near Science Hill. This series is intermediate between *pernix* and *longicauda*, but seems closer to *pernix*. **Todd County:** (4), May 8, 1952, Clifty; (2), March 20, 1953, Jefferson Davis Monument State Park; (2), June 11, 1953, Clifty; (3), April 9, 1954, 2 miles east of Allegre. **Warren County:** (1), April 10, 1953, 2 miles north of Hadley.

There are several specimens of *Eurycea longicauda longicauda* in the University's collections, all of them from the east and north of the known range of *pernix* in the state. The location of the area of intergradation of the two subspecies in the state is a matter of continuing research.—ROGER W. BARBOUR, *Department of Zoology, University of Kentucky, Lexington, Kentucky.*

A BALL OF GARTERSNAKES.—At the suggestion of Dr. A. H. Wright, I shall try to describe a "ball" of gartersnakes I saw on April 18, 1954. I have learned something of the habits of these snakes since then, so their actions are more understandable to me now than when I observed them.

At noon, I walked along the foot of a steep wooded bank that had a northerly exposure. The ground cover was a mixture of hemlock needles and dry leaves; there were occasional patches of sunlight near the foot of the slope. As I passed an open spot, I heard a steady rustling noise in the leaves, and looked up to see several gartersnakes writhing actively in a patch of sunny ground above me. My approach to within 10 feet of the snakes disturbed them only momentarily; they resumed their activities a few seconds after I stopped moving. The snakes were quite tangled up, and I could not understand the meaning of this strange behavior; they were not biting or strangling one another, and none made any attempt to leave the group when they occasionally broke free from one another. At this time there were four or five snakes.

As I stood watching this performance, I heard rustlings in the leaves and noted a number of snakes approaching from all directions. These snakes had evidently halted at my approach and were resuming their course after I had stood still for some time. Now I could see snakes approaching from as far away as 20 to 25 feet in several directions, all of them heading straight for the group of the entangled four or five. The day was bright, clear, and cool, but very warm in the sun, and there was a quite continuous breeze. Several snakes were coming from straight up wind.

As a snake arrived at the "ball," it paused for a moment and then entered into the writhing mass. In the course of about 10 or 15 minutes the group had enlarged to some 15 or 20 snakes.

After a while I did discern a pattern to the behavior. The heads and a short section of the bodies of most of the snakes were generally parallel and extended out from one side of the mass. A new arrival, when first coming upon them, would hesitate, apparently look over the tangle, and then would work its way into the group, and very shortly another head would appear alongside the others. I do not mean to imply that the heads and upper bodies were closely or strictly grouped, but there was a tendency toward this organization. The tail ends of the snakes were in a hopelessly tangled mass of violent action.

The movement of the snakes caused them to slip gradually down the hillside for several feet; at one point the whole mass rolled down as a ball for 4 or 5 feet, with hardly a noticeable break in the tempo of the action. This brought the snakes very close to me, and it was at this time that I noticed the rough organization of the individuals within the ball.

All at once one of the larger snakes having, as I remember, a thicker but not so brightly colored body as the others, left the mass and quickly moved 3 or 4 feet away; it was followed by a couple of smaller ones. The organization and tempo of the main ball of snakes immediately fell off and a number of them commenced to wander away, apparently aimlessly. The two pursuers of the heavier snake approached it hesitantly and then brought themselves parallel to it and pressed their bodies against it at about the mid-point, as if they were trying to upset it or press underneath it. Again their heads were roughly together, their bodies arched, probably to facilitate the pressing as noted, and their tails writhing and tangling in complete disorder.

As soon as the two snakes started their antics with the one which had escaped, most of the other snakes converged on them and again the whole group massed together as they had been before; however, several of the snakes wandered off, apparently having lost interest.

Within another 5 minutes the group again was broken up by the exit of a large snake (it may have been the same one as before). I then ceased my observation as I had already delayed three-quarters of an hour for a Sunday dinner with my family.—J. B. GARDNER, *Seymour, Connecticut.*

REPRODUCTION AND DEVELOPMENT IN THE NORTHERN DIAMONDBACK TERRAPIN, *MALACLEMYS TERRAPIN TERRAPIN*.—During the summer of 1953, the opportunity arose for observing the nest and parts of the embryonic development of the northern diamondback terrapin, *Malaclemys terrapin terrapin* Schoepff. Carr (1952, Handbook of turtles: 167–8) pointed out the abundance of information on the biology of captive diamondbacks and the extreme paucity of natural history data on the reptile in its natural environment. In a similar vein, McCauley (1945, The reptiles of Maryland and the District of Columbia: 165) indicated the lack of known details in the life cycle of the northern diamondback.

On June 9, 1953, a female *Malaclemys terrapin terrapin* was discovered in the act of depositing eggs, approximately 4 miles west of Yorktown, Virginia, along the Colonial Parkway. The nest had been scooped out of sand heavily laden with shell fragments. This soil in which the nest was dug had apparently been brought in to provide a fill for the highway across what was previously a low, tidal marsh area. Vegetation in the immediate area is quite sparse and a typical salt marsh, with tidal creek, is located approximately 60 feet from the nesting site. The terrapin was found at 9:00 AM. Although the air and water temperature were not

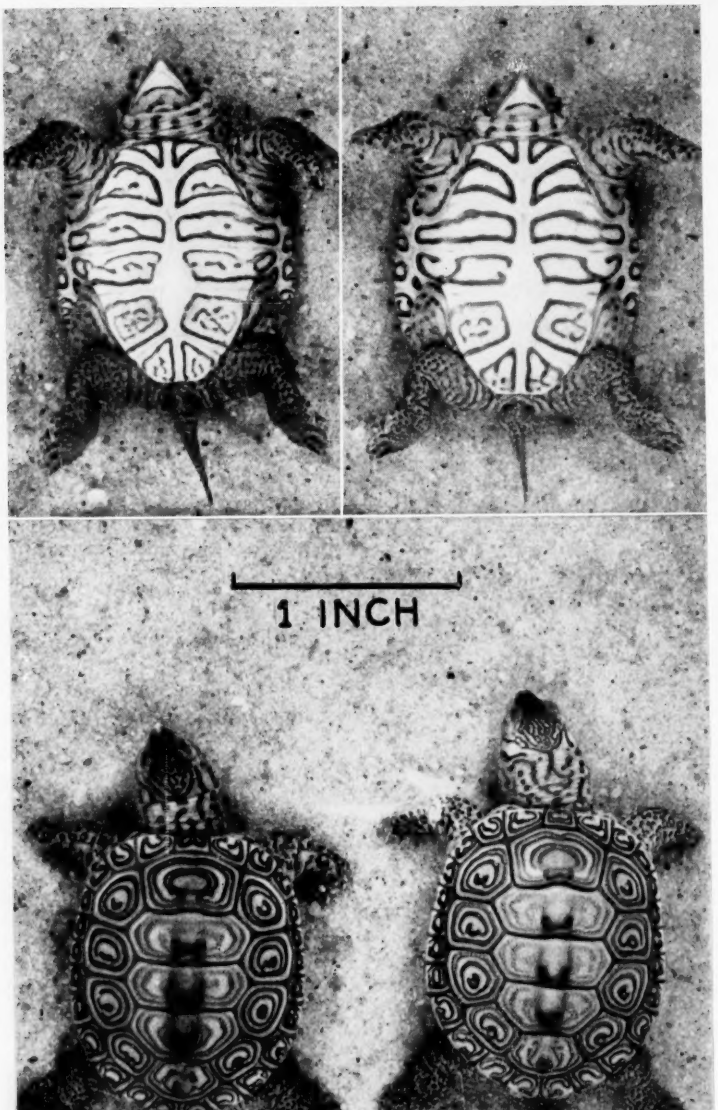

PHOTO BY BOB BAILEY, VIRGINIA FISHERIES LABORATORY

Four hatchlings of *Malaclemys terrapin terrapin*, 4 days old.

ascertained at the immediate locality, the Virginia Fisheries Laboratory, approximately 5 miles east, reported the air temperature as 90° F. and that of the water as 78°.

The topsoil of sand and shell fragments in which the nest was excavated was hot and dry at the surface, although it was rather moist at an approximate depth of 5 inches. The nest was roughly triangular as viewed from above, being about 4 inches long on one side and 3 on each of the other two. A parapet, approximately 1½ inches high, had been thrown up around the two shorter sides. The terrapin, facing outward, occupied the widest side of the opening. At the time of discovery the eggs had already been laid and had been covered with sand; the depth from the top of the parapet to the sand cover was 4½ inches.

When first approached, the terrapin made no attempt to leave the nest. After approximately 10 minutes, photographing was begun, and, as might be expected, she began moving toward the marsh. She was replaced in her original position for photographing, after which she was removed for morphological study.

Examination of the nest revealed that one egg was buried at approximately 6¾ inches, two at 7, and four at about 7½ inches below the surface. One of the eggs was accidentally broken; the other six were placed in a container, and covered with some of the local soil. The soil was kept at room temperature and was dampened occasionally. The elongate ovoid eggs of this clutch were not measured, but McCauley (*op. cit.*) reported 12 that averaged 31.1 by 21.2 mm.

One egg was sacrificed on June 12, 34 days after being laid. This egg contained an embryo with the following dimensions: carapace 11 mm. long, 8.25 mm. wide and 4.75 mm. high; head 7.5 mm. long; eye 3.5 mm. in diameter.

Four of the remaining five eggs hatched on August 16, the 69th day. The first individual broke the surface of the soil near noon and within 2 hours three more hatchlings were recovered. The young were kept alive until August 20, on which date they were photographed, preserved and measured. Measurements (in mm.) of the four-day-old terrapins are, respectively: carapace length—27.0, 27.0, 28.5, 27.0; carapace width—27.0, 27.0, 28.5, 27.0; plastron length—28.0, 26.0, 28.0, 26.0; plastron width (from point of articulation of pectoral, abdominal, and marginal laminae on either side)—23.5, 23.0, 24.0, 24.0. These measurements compare closely with those of two hatchlings reported by McCauley (*op. cit.*) as follows: carapace length—30.5 and 31.0; plastron length—26.5 and 26.0.

The carapace of the mother was 190 mm. long, 153 mm. wide. The plastron was 175 mm. by 134 mm. Markings on the head were atypical in that they tended toward lengthwise dark lines rather than the more characteristic spotting. The hatchlings showed similar markings (Plate I).—GEORGE K. REID, JR., *Department of Wildlife Management, A. and M. College of Texas, College Station, Texas.*

RANGE EXTENSION OF *GASTROPHRYNE CAROLINENSIS.*—Blair (1952, COPEIA, (2): 115) reported *Gastrophryne carolinensis* one mile west of Salina, Mayes County, Oklahoma. It was felt at that time that this collecting station probably marked the western edge of the range of this species in northeastern Oklahoma. It has since become apparent, with the taking of specimens 7 miles west of Inola, Wagoner County, and 5 miles northeast of Tulsa, Tulsa County, that this eastern woodland form follows heavily wooded floodplains westward into the prairie.—ALBERT P. BLAIR AND HAROLD E. LAUGHLIN, *Department of Zoology, University of Tulsa, Tulsa 4, Oklahoma.*

APOSEMATIC BEHAVIOR IN THE SALAMANDER *AMBYSTOMA TIGRINUM MELANOSTICTUM.*—The recent note of A. Stanley Rand (1954, COPEIA, (3): 223–4) on tail-waving activity in *Ambystoma jeffersonianum* has induced me to report the following observations on similar behavior in *Ambystoma tigrinum melanostictum.*

Between 10:00 PM and 1:30 AM, July 28, 1951, during a light rain, following a day of continued rain, I was traveling the paved highways in the Jackson Hole region of Wyoming in search of amphibians. Many tiger salamanders were moving across the roads, especially in the areas bordered by sagebrush flats. When captured on the road, some individuals exhibited what I believe to be aposematic behavior.

When first observed, a crawling salamander which I was approaching suddenly stopped, spread and arched its hind legs, raised its tail almost to the vertical and then waved it back and forth. When placed back on the road after capture, it repeated the tail-waving behavior, but after continued prodding, it ceased this activity and quickly started to crawl away. Later, I noticed that at least five of twelve salamanders observed also exhibited this response of tail-waving, on approach or after slight prodding.

The effect of this tail-waving is quite spectacular. While the bulk of the salamander is held motionless near the substrate, the raised tail, with its black and yellow blotched pattern, waving continuously, could very well serve to frighten away a small predator and perhaps startle a large one for a period long enough to permit escape.—CHARLES C. CARPENTER, *Department of Zoology, University of Oklahoma, Norman, Oklahoma.*

OBSERVATIONS ON TWO SPECIES OF LIZARDS IN THE CHIHUAHUAN DESERT.—As many herpetologists know, great efficiency in collecting reptiles can be reached by driving an automobile about 5 miles per hour with one or two collectors riding the front fenders. In about 28 collecting days during June and July, 1954, the three authors caught 90 earless lizards and 40 bleached horned lizards alive. Over 200 other specimens of amphibians and reptiles were either caught alive or were shot. Collection ranged from central Kansas to Ciudad Chihuahua, Chihuahua, and west to Gila Bend, Arizona. The miscellaneous observations recorded herein will be followed at a later date by an annotated list of the forms collected.

Holbrookia m. maculata Girard.—On June 17 on a gravel road in Parmer County, Texas, two of these lizards were observed whirling around each other. The smaller one was grasping with its mouth the back of the neck of the other. When they were caught, it was found that the former was a male with its hemipenis exposed; the latter was a female, containing several eggs. This same behavior pattern was observed in another pair in a cage on July 13. In neither instance was actual copulation observed.

Phrynosoma modestum Girard.—The eviscerated body of a bleached horned lizard was found impaled on a twig of a bush 1 mile NE of the Carrizozo malpais in New Mexico. On July 21, 2 days after being brought back from the field, a bleached horned lizard was observed laying eggs in a cage. The lizard first dug a hole about 1¼ inches deep in the damp sand in the corner of the cage. The nine eggs laid were pink, with a red spot about 2 mm. in diameter on one side; they were about 7.0 to 8.0 mm. long. The lizard covered the eggs by scratching sand with the front legs, then kicking it back with the hind ones. She covered them with about 2 inches of sand, taking at least an hour to do so.—ROY E. BUNDY, DELBERT MEYER, AND JOHN NEESS, *Department of Zoology, University of Wisconsin, Madison 6, Wisconsin.*

REVIEWS AND COMMENTS

RYBY SEVERNYKH MOREI SSSR. Opredeliteli po Faune SSSR, Zoologicheskil Institut Akademii Nauk SSSR, Moscow, No. 53, 1954, 566 pp., 297 figs., many tables, [Fishes of the northern seas of the U.S.S.R. Guides to the Fauna of the U.S.S.R.; published by the Zool. Inst., Acad. Sci. U.S.S.R.] by A. P. Andriiashev.—Numerous Soviet expeditions and many investigators have studied the marine ichthyofauna of the Soviet Arctic since the publication, in 1926, of Knipovich's "Studies of the fishes of the Barents, White and Kara Seas." Andriiashev's long continuing studies in this region especially qualify him for the task of bringing together this information. Although new data are presented, this work primarily summarizes information published previously. The manuscript has been in press, or otherwise withheld, since 1949. Data published from 1949 to 1953 are reviewed in the addendum (pp. 532–44).

The text discusses the fishes of the five major seas of the Arctic shores of the Soviet Union (the Barents, Kara, Laptev, East Siberian and Chukchi seas), the White Sea, the coastal regions of northern Norway and Spitzbergen, and more northern and deeper portions of the Arctic Ocean proper. Some records from Iceland, Greenland, the Bering Strait and Alaska are also included.

In all, 222 species and 16 subspecies (excluding natios) are treated. Of these, *Coregonus peled*, *C. nasus*, *Thymallus arcticus*, *T. thymallus*, *Esox lucius*, *Lota lota*, *Cottus gobio*, *C. sibiricus* and *C. kaganowskii* are freshwater fishes which only occasionally enter river mouths and brackish waters.

A distributional summary is presented in tabular form (pp. 523–31). The column titled "the shores of Norway" does not include all fishes known from this region but only those species which also occur in the northern seas. Records and corrections listed in the addendum have been incorporated into the table so that it disagrees, in some instances, with the body of the text. The reproductions of drawings and photographs are excellent. Most illustrations have been taken from other works but many, including several of zoarcids, are new. Of especial interest are the numerous original roentgenographs which show remarkable amounts of detail.

Each form is treated as follows: A regional synonymy is given which includes only those names based on material from localities in the Soviet Arctic. Next follows a selected list of references to the distribution and biology. Although incomplete, this section is very useful because of brief annotations. (There is no inclusive bibliography at the end of the work.) A brief description follows which considers

meristic features (including vertebral counts), body proportions, coloration and general morphology. Except for a few tables, most of this information seems to be taken from the literature. A discussion of commercial importance is given for the better-known species. A general summary of the total distribution is then given. A section entitled biology completes the discussion of almost every form. This section is very brief although considerable data on the life history, age and growth, food and catches are given for the better-known or commercially important species. Such information is taken mostly from the literature.

Keys are given for the identification of all families, genera, species and subspecies. Indices are proxided to the scientific and Russian names of the fishes. Typographical errors are corrected on an errata sheet which is inserted at the end of the book.

In general the taxonomy is conservative. The name changes which are listed in the table on pages 5–6 of the introduction are not employed for the first time in this work. They are changes which have been made since the publication of Knipovich's treatise and most, if not all, are of long standing in the literature.

The coregonids are included in the family Salmonidae, and the family Thymallidae is retained. Contrary to the views of Berg, the genus *Icelus* is retained in the family Cottidae, and the liparids are maintained as a family distinct from the Cyclopteridae. Perhaps of greatest interest is Andriiashev's treatment of the zoarcids, in particular that of the genera *Gymnelis* and *Lycodes*. Additional information on these forms is given in the addendum. The emphasis placed on color pattern and dentition in arranging the species of *Lycodes* needs additional study. On pages 536–7, *Lycodes coccineus* Bean and *L. knipowitschi* Popov are listed as subspecies of *L. mucosus* Richardson and, similarly, *L. agnostus* Jensen is considered a synonym of *L. polaris* Sabine. Walters (Bull. Amer. Mus. Nat. Hist., Vol. 106, Art. 5, in press), however, considers *L. polaris* as probably identical with *L. jugoricus* Knipovich, *L. mucosus* as an Arctic species distinct from other naked eel pouts, and *L. coccineus* and possibly also *L. knipowitschi* as conspecific with *L. turneri* Bean. *Lota lota leptura*, considered a valid subspecies by the reviewers, is reduced to the category of natio. This category is employed to a lesser extent than in other recent Soviet works. *Pleuronectes* as employed by Andriiashev equals *Platichthys* of American and British ichthyologists.

It is regrettable that Dr. Andriiashev has not presented his views on the zoogeography of the region; much information has been published since the appearance, in 1939, of his earlier work on the zoogeography of the Bering Sea. As a work which both summarizes the considerable literature on the marine ichthyofauna of the Soviet Arctic and presents new data, this book is of great importance to the student of northern fishes.—C. RICHARD ROBINS AND VLADIMIR WALTERS, *Department of Conservation, Cornell University, Ithaca, New York and the American Museum of Natural History, New York, New York.*

EVOLUTION OF THE VERTEBRATES. By Edwin H. Colbert. John Wiley and Sons, Inc., New York; Chapman and Hall, Limited, London, 1955: xiii + 479, 122 figs. $8.95.—The author's preface says this book is for the general student and the lay reader and that it is not concerned with the mechanisms or principles of evolution, but with a survey of the fossil record of the vertebrates. Happily for the scientific public, these modest aims are surpassed often enough to result in a wealth of factual information interspersed with interesting speculation. That the book is much more than a serial presentation of the fossil record, is amply demonstrated in chapters such as those entitled "From water to land," "Conquest of the land," and "Evolution of the Primates"; these as well as others are narrated in excellent fashion and are marred by singularly few misleading statements. An annoying one, however, is found in the otherwise fine account of the problems faced by the first vertebrate land-dwellers, the amphibians. Like Romer in his *Vertebrate Paleontology*, Colbert tells us categorically that amphibians are forced to return to the water to lay their eggs. The exceptions in present-day forms are so numerous that such a statement in a modern work is hardly excusable. The text is amply illustrated with well-executed drawings, most of which were drawn expressly for the book by Mrs. Lois Darling who also did the attractive sketches that head each of the 30 chapters. Dr. Colbert's admirable attempt to write for the general student and lay reader is remarkably successful, and only rarely overly obvious. Perhaps the least revealing statement in the book is that *Castoroides* attained a size comparable to that of a small bear. The author and editors will be chagrined when they find out that the meaning of Oligocene is antithetical to the one given in the book. This very readable, important work will be of great value to the biological departments of colleges and of those universities without trained vertebrate paleontologists.—NORMAN HARTWEG, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

Editorial Notes and News

AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

SUMMARY OF 1955 MEETING

THE thirty-fifth annual meeting of the Society was held jointly with its Western Division at the California Academy of Sciences in San Francisco, June 27–July 1, 1955.

Activities of June 27

The Governors were guests of Dr. and Mrs. William I. Follett at a delightful dinner at the Cliff House in San Francisco. Immediately thereafter, the Governors convened at the California Room of the Whitcomb Hotel.

The meeting of the Board of Governors was called to order by President Edward C. Raney at 8:30 PM. Thirty Governors were present. The Secretary read messages from Drs. Goin, Yerger, Howell, Atz, Schmidt, Lagler, Schaeffer and Riggs, expressing their regret that they would be unable to attend the meeting. The President read an additional telegram from Graham Netting and Neil Richmond. He also requested that the Secretary transmit a good-will message from the group to Dr. Goin, wishing him a speedy recovery.

It was moved and seconded that the minutes of the 1954 meeting stand as published in Copeia, 1955, (1): 72–80. Motion passed.

The first item of business was the election of ten new members of the Board of Governors. The President reminded the Governors that retiring members of the Board were not eligible for immediate reelection. The President also pointed out that it would be helpful to the Board to have the counsel of the retiring editors and vice-presidents. The following persons were elected to the class of 1960: Frances Clark, Gerald Cooper, Norman Hartweg, James Keezer, Lawrence Klauber, Ernest Lachner, Robert R. Miller, Margaret Storey, Charles Walker, and Norman Wilimovsky.

Dr. Robert C. Stebbins, Vice President for Conservation, reported that the proposed Echo Park Dam had been deleted from the Upper Colorado River project, so that the Dinosaur National Monument will not be flooded, at least for the time being.

Dr. Carl Hubbs stated that he would like to have an expression of opinion regarding a situation in the Death Valley area where there have been local moves to take some of the isolated springs in the area from the Park, or to oppose putting some of the areas in the Park, on the grounds that some of the warm springs might make nice health or pleasure resorts. He stated that this is distressing to those who have been concerned with the very high endemism of the fishes and aquatic insects in some of the waters, such as Saratoga Springs, which is one of those in question. Dr. Hubbs said he thought it would be well if the Society would go on record as favoring the retention in, or addition to, the National Park Service of isolated desert waters with endemic fish and other endemic fauna, so if this question comes up in any controversy, it can be pointed out that the Society favors retention.

After further discussion, the President appointed Dr. Hubbs to act as chairman of the Resolutions Committee and to draw up an appropriate resolution to be transmitted to the Vice-president in charge of Conservation.

Dr. Stebbins noted that a rare salamander had been discovered at Aptos, just south of San Francisco Bay. He believed it to be within the State Park but recommended that the Society go on record for the preservation of this form, or at least call attention to it and our desire to see the species protected. It was decided to put this matter also in the hands of the Resolutions Committee.

Dr. Frank Blair reported that Ezell's Cave in Texas is now under the control of the Texas Herpetological Society. Anyone wishing permission to collect there should write to the secretary of that organization, which has a committee (Dr. Blair is a member) that handles applications.

Dr. Gerald Cooper, Editor-in-Chief of Copeia, in his report, explained that with the printer in Baltimore and the editorial offices in Ann Arbor, it is difficult on a four-number-per-year schedule, to receive a paper from one of the divisional editors and get it published within three months. The Editors are therefore operating with one complete issue in holdover matter, both feature articles and notes. He also pointed out that, if Copeia were reduced in pagination as an economy measure, some papers would have to be turned down in the future, which has rarely been done in the past.

Dr. Cooper made the point that individual copies of Copeia occasionally appear with printing mistakes, and members should have no hesitation in returning them to the Secretary for replacement.

DR. COOPER asked for advice concerning the question of common names of amphibians and reptiles. Assuming that such a list would be published in COPEIA, he felt it desirable to establish a common format for both herpetological and ichthyological names. MR. CONANT explained that the Committee on Herpetological Common Names had nearly completed its work; that he had canvassed the members of his committee some months ago as to their ideas of style; and had forwarded his suggestions to DRS. COOPER and HARTWEG stating that he was ready to work with the Editors for some mutual system that would be to everyone's advantage. DR. REEVE M. BAILEY also stated that he felt there should be some liaison between the Herpetology Committee and the Committee on Fish Nomenclature, of which he is chairman. DR. BAILEY further suggested that if the lists are published in COPEIA, reprints should be made which could be sold separately. He stated that the list which appeared seven years ago in the *Transactions of the American Fisheries Society* had been published as a reprint, sold at 25 cents a copy, and that 3,000 of the 4,000 reprints had been sold.

PRESIDENT RANEY announced that the editorial staff of COPEIA was resigning en masse, marking the first time since 1930 that the editorial duties would not be performed by a group at Ann Arbor. He felt sure that DR. BOYD WALKER, Chairman of the Nominating Committee, would welcome any suggestions members might have to offer as to possible successors to the Editors.

In the absence of a report from the Publications Committee, PRESIDENT RANEY reported that the publications secretary is DR. N. B GREEN, Marshall College, Huntington, West Virginia. According to PRESIDENT RANEY, DR. GREEN has taken care of the back numbers of COPEIA for a number of years, and the Society receives about $600 to $1,000 a year from the sale of these back numbers, which has helped to keep the Society solvent over the past four or five years. In response to a question from DR. GOSLINE, PRESIDENT RANEY explained that it is no longer possible to get a complete set of COPEIA, and that it would take $20,000 to $30,000 to reprint all of the missing issues. DR. GREEN periodically publishes a mimeographed list of available back numbers.

DR. GROBMAN distributed copies of the Treasurer's Report in the absence of DR. GOIN. DR. GROBMAN brought up a problem which DR. GOIN was concerned about in connection with the endowment fund. The endowment fund is made up of monies collected from life memberships, and in the past the interest from that endowment fund has been used variously. Sometimes it has been incorporated in the endowment fund and sometimes put into the general Society account. DR. GROBMAN explained that DR. GOIN and he felt it should always go into the general account and that DR. GOIN would like to have confirmation from the Governors to act accordingly. The motion was made and carried that the income from the endowment fund hereafter be placed in the checking account.

PRESIDENT RANEY stated that the Society has been operating on a surplus of funds built up during good years and that unless present income is supplemented, the organization will be in the red.

DR. GROBMAN reported that he had also discussed with DR. GOIN the matter of approximately $3,000 in the checking account. Normally when the general account has built up to a sizable amount, the surplus has been placed in government bonds but it was felt that it might be desirable to put this additional surplus in other investments that would provide a higher interest return. DR. KLAUBER, Vice-President in charge of Finances, stated that his committee would be willing to recommend the investing of a sum as advantageously as possible. A motion was made and carried that the officers be authorized to withdraw an appropriate sum from the checking account and, with the advice of the Vice-president in charge of Finances, to use this money for investment.

PRESIDENT RANEY stated that the Treasurer's Report was audited by DR. ARCHIE CARR and his committee of three and found correct.

After a discussion of why the Herpetological Check List has been moving so slowly, a motion was made and carried that a greater effort be made to get reviews, news notes and advertisements about the List in appropriate journals. The President was instructed to take necessary action.

As Secretary, DR. GROBMAN summarized the conclusions made from an operating expense analysis. Certain expenses, such as AIBS dues, administrative and operating costs, are relatively fixed. He recommended that a budgetary system for operating should be followed, and proposed that 76 percent of the money received from dues and subscriptions during one year should be applied to expenditures for COPEIA for the subsequent year. With present dues, that would mean less pages than are now being published. DR. GROBMAN then explained that if a figure of $21 per page were used in an analysis of costs it would cost about $6500 annually to print 300 pages of COPEIA. If the dues were raised one dollar—from $5.00 to $6.00 and subscriptions from $6.00 to $7.00—and 76 percent of this sum were utilized for COPEIA, it would provide only $6100. If dues were raised two dollars—from $5.00 to $7.00, and subscriptions were raised to $8.00—then 76 percent of that sum would net an income of $7100, which would allow the Society to publish more than 300 pages annually. DR. GROBMAN suggested that on such a basis, the Editor could be instructed, at the beginning of each year, that he has a certain amount of money to spend—whatever 76 percent

might give him—and he could proceed on that basis. The number of pages would vary according to this amount, but this sum should insure at least 300 pages annually, even though printing costs should go up. DR. GROBMAN also reported on an analysis made by DR. KILBY and himself of 40 national biological societies, the amount of dues they collect, the size of their membership, and the number of pages they publish each year. DR. GROBMAN said that he felt that if dues were to be raised, he would suggest domestic members' dues be $7.00; foreign, $6.00; subscriptions, $8.00; and life memberships, $125.00.

PRESIDENT RANEY pointed out that for the past two years the Society has been spending about $1,000 more for COPEIA than it has been receiving in membership dues and subscriptions. In reply to a question, PRESIDENT RANEY predicted that there might be a loss of about 100 members if dues were raised. In the following discussion it was the consensus of opinion that it would not be wise to eliminate membership in AIBS, nor to reduce the number of pages in COPEIA. DR. GROBMAN explained that a bid from another printer on one issue of COPEIA had also been obtained and it was $50 higher than the present printer's costs, and this did not include engraving expenses. It was felt that printing News Notes in a mimeographed supplement would not save much money when time costs and postage were included.

After further discussion, DR. BLAIR made a motion that no change in dues be made this year and that an intensive membership drive be made. Considerable discussion indicated that past membership drives had not resulted in any great permanent increase. An amendment to the motion was made and accepted, that dues and subscriptions be increased one dollar and life memberships be increased to $125. Hence, the schedule would be: domestic members, $6.00; foreign, $5.50; subscriptions, $7.00; and life, $125. The life membership could be paid in five annual installments. DR. HUBBS later rephrased this as an amendment to the By-laws and it was passed with one dissenting vote. DR. GOSLINE pointed out that he and some other life members had obtained their memberships for $75, and that he felt most such members would be happy to make a contribution to the organization to go toward the publication of COPEIA. DR. GROBMAN spoke against such a feeling of moral responsibility on the part of life members suggesting that the Society, when it offered such memberships, was entering into a contract which it was obligated to fulfill.

At the Secretary's request a motion was made and passed that a change be made in the wording of Article IV, Section 4 of the Constitution which stated that "Incumbent officers of the Society, including members of the Western Division, shall be members of the Board." This was changed to read: "... including those of each recognized division."

DR. GROBMAN stated that he had a request from a foreign member who wanted to become a life member but felt that there should be a reduced cost for foreign life members. The Governors declined this suggestion and insisted on a single fee for life members.

DR. GROBMAN brought up the matter of exchange copies of COPEIA. Since the Society does not maintain a library itself, it was suggested that individuals might personally wish to take advantage of these exchange offers. No member has indicated interest over the past few years. A motion was made and passed that the Board of Governors authorize the Secretary to refuse all exchanges in the future and that if there should be any interest in such exchanges among individuals, they should handle them personally.

DR. GROBMAN reported that he had been investigating the matter of the availability of snap-top glass jars, through AIBS. He has been working with his local congressman to see if it would be possible to import jars duty-free and also to accept jars that would presently be rejected under the inspection standards insisted upon by the Customs Bureau for jars to be used in canning. Progress is being made and it is hoped that the 84th Congress will pass appropriate legislation.

DR. GROBMAN asked that Article IV, Section 1, be amended. It now reads, in part, "A treasurer, a secretary, and a publications secretary, all of whom must be re-elected annually, ..." A motion was made and passed to substitute "may" for "must."

DR. JAY SAVAGE brought to the attention of the Board of Governors two major points: (1) the possibility and advisability of publishing the Herpetological Check List at regular intervals in the future, and (2) the advisability of having the Check List prepared in the future by a committee rather than a single individual. He said he had been in correspondence with DR. SCHMIDT, who has stated he would personally like to prepare the next edition of the Check List in approximately 1960, and that he would publish it elsewhere if the Society were unable to do so. PRESIDENT RANEY pointed out that the Society has funds invested in the present edition which should be recovered before a new Check List is brought out. In regard to a committee to prepare the Check List, MR. CONANT pointed out that such a committee had been named several years before, with DR. SCHMIDT as Chairman. When the committee found it impossible to function, due to limitations on time, DR. SCHMIDT went ahead and prepared the List himself. MR. CONANT suggested that DR. SCHMIDT be permitted to go ahead with plans for a new Check List and perhaps the question

could be raised again when subsequent editions are considered. This seemed to express the consensus of the group.

DR. ROYAL SUTTKUS reported for the Committee on a COPEIA Index. He described how DR. CLYDE F. REED and he had been working independently on such an index for several years. DR. REED began sending his material to DR. SUTTKUS for checking, and in December, 1954, sent a manuscript of the authors' index, with a letter stating that he wished to get it published by January 1. DR. REED was advised that it would be impossible to process the manuscript in that time, and that the Society had not as yet authorized publication. Several months later DR. SUTTKUS was informed by DR. REED that he had contacted publishers and he was proceeding to publish the Index privately. DR. REED advised that he had put about $600 into the project and was informing members that the Index could be purchased at a pre-publication price of $3.00 each part and a publication price of $4.00 on each part. DR. SUTTKUS stated he did not believe there was any further action the Society could take in the matter.

DR. GEORGE S. MYERS, Chairman of the Committee on Fish Classification, reported that the committee has not been active.

DR. GROBMAN reported that the Society usually makes an annual contribution to the *Zoological Record* of about $140. A motion was made and passed that a similar contribution be made this year.

There was no announcement from the Western Division.

The Southeastern Division reported that the 1955 meeting would be held during the first week in October at Highlands, North Carolina.

DR. GROBMAN asked that the Board consider a revision of a ruling of some years ago that no monies be given to divisional officers from the national treasury. He stated that the divisions are carrying on mailing that benefits the Society and asked that they be allowed postage. MR. CONANT stated that as he was a holder of a $75 life membership, he would like to contribute enough this year to take care of the postage expenses of the two divisions.

PRESIDENT RANEY brought up the question of a site for the next meeting. No invitations had yet been received and it was felt that the next meeting should be in the midwest. It was pointed out that next year the AIBS would be meeting in Storrs, Connecticut, and a joint meeting could be considered. It was moved that the matter of a site for the next meeting be left in the hands of the officers to decide; motion carried.

DR. FOLLETT read a letter from DR. R. E. BLACKWELDER of the Society of Systematic Zoology, pointing out that his society was planning a Congress of Systematic Zoologists at the AAAS meetings during December, 1958, in Washington, D. C. The ASIH was invited to cooperate. The matter was left in the hands of the officers.

DR. VLADYKOV suggested that it might be possible to increase returns from COPEIA by running advertisements in it, but DR. HUBBS pointed out that this matter had been looked into some years ago and it was found that increased mailing costs which would arise from the loss of second-class mailing privileges would overbalance any revenue received from advertising. PRESIDENT RANEY said he felt this was a matter that should be re-investigated by the officers and that it would be done. DR. VLADYKOV also recommended that COPEIA publish a supplement dealing strictly with taxonomy, possibly three times a year. DR. HERALD suggested that this be referred to the Publications Committee.

The meeting was adjourned at 11:45 PM.

Following the meeting, PRESIDENT RANEY appointed the following committees:

On Resolutions:
CARL L. HUBBS, Chairman
WILLIAM GOSLINE
HOWARD EVANS

On Herpetological Fred Stoye Prizes:
FRED CAGLE, Chairman
W. FRANK BLAIR
WALTER C. BROWN

On Ichthyological Fred Stoye Prizes:
JOHN MARR, Chairman
ROYAL D. SUTTKUS
WILLIAM B. SCOTT

ACTIVITIES OF JUNE 28

Registration was held in the lobby of the Morrison Planetarium. A total of 129 persons registered but larger numbers attended many of the sessions.

The first formal session was convened by PRESIDENT RANEY in the Morrison Auditorium at 10:00 AM. After a very cordial address of welcome by DR. FOLLETT, speaking in behalf of the California Academy of Sciences, the following papers were presented:

A Preliminary Report on Some Investigations in Philippine Herpetology.—Walter C. Brown, Stanford University.

Ecological Aspects of the Behavior of Cyprinodon macularius in the Salton Sea—George W. Barlow, University of California, Los Angeles.

Some Remarks on the Distribution of the Yellow-bellied Sea Snake, Pelamydrus platurus.—Alan E. Leviton, Stanford University.

Length of the Intestine in Sardines.—Wilhelm Harder, University of Hamburg.

Ecological Interpretation of the Distribution of the Himalayan Herpetofauna.—Lawrence W. Swan, San Francisco State College.

Food Selectivity by the Gulf Croaker in the Salton Sea.—Jay C. Quast, University of California, Los Angeles.

At noon, members and guests assembled for a group photograph on the steps of the Planetarium building. After lunch, the joint symposium on Aquaria was convened by DR. EARL S. HERALD and the following reports were given:

AQUARIUM DESIGN, CONSTRUCTION, AND MATERIALS

The Multisystem Aquarium: The New York Aquarium.—Christopher W. Coates, New York Aquarium, New York Zoological Society.

The Oceanarium: The First Six Months of Marineland of the Pacific.—Kenneth S. Norris, Marineland of the Pacific.

The Marine Station Aquarium: T. Wayland Vaughan Aquarium-Museum.—Sam D. Hinton, Scripps Institution of Oceanography.

The Inland Aquarium: The New James R. Record Aquarium. Lawrence Curtis, Fort Worth Zoo and Aquarium.

The Use of Plastics in the Aquarium.—Ross McBride, Ocean Aquarium, Hermosa Beach, California.

General Discussion of Materials: Pumps, Pipes, Valves, Tanks, etc.—Leader: Earl S. Herald, Steinhart Aquarium, California Academy of Sciences.

BEHAVIOR OF FISH AND OTHER AQUATIC VERTEBRATES

Special Problems in the Maintenance of an Oceanarium Exhibit.—F. G. Wood, Jr., Marine Studios, Florida.

Behavior of Temperate Marine Fishes.—Earl S. Herald, Steinhart Aquarium, California Academy of Sciences.

Behavior of Tropical Freshwater Fishes.—George S. Myers, Stanford University.

Behavior of Trout and Salmon.—Murray A. Newman, University of British Columbia.

Collection and Confinement in Captivity of Two Species of Pacific Dolphins, Delphinus bairdi and Lagenorhynchus obliquidens.—David Brown, Marineland of the Pacific.

Arrival of Tursiops from Florida.—David Brown, Marineland of the Pacific.

The Symposium continued after dinner with DR. CHRISTOPHER W. COATES presiding. The following papers were heard:

Porpoises of the Atlantic Coast.—F. G. Wood, Jr., Marine Studios, Florida.

WATER IN THE AQUARIUM WORLD

Portable Salt Brine for Dilution by Inland Aquaria.—Maurice Rakowicz, San Francisco Aquarium Society.

DISEASES AND DISEASE CONTROL

Epizootics in California Freshwater Fishes.—Joseph H. Wales, California Department of Fish and Game.

Trout Hatchery Diseases vs. Hatchery Practice and Design.—Harold Wolf, California Department of Fish and Game.

Demonstration of Control for Oodinium ocellatum.—Robert P. Dempster, Steinhart Aquarium, California Academy of Sciences.

FOOD AND NUTRITION

Problems in the Use of the Brine Shrimp as a Fish Food.—Maurice Rakowicz, San Francisco Aquarium Society.

COLLECTION AND TRANSPORTATION OF FISHES

Salt-Water Fish Transportation Equipment.—Kenneth S. Norris, Marineland of the Pacific.

Demonstration of the Venturi Principle as Applied to the Circulation System of a Fish-Planting Truck.—Personnel of the California Department of Fish and Game.

The Use of Metabolism Inhibitors in Collecting and Transporting Fishes.—Wm. McFarland, University of California, Los Angeles.

The Aqualung in the Collection of Living Materials for Aquarium Display.—Conrad Limbaugh, Scripps Institution of Oceanography.

THE PHILOSOPHY AND PRACTICE OF AQUARIUM EXHIBITION

Aquascaping Small Display Tanks in Public Aquaria.—Donald A. Simpson, Steinhart Aquarium, California Academy of Sciences.

Legends and Labels.—Sam D. Hinton, Scripps Institution of Oceanography.

ACTIVITIES OF JUNE 29

The morning session was co-sponsored by the Herpetologists League and, with DR. ANGUS M. WOODBURY serving as chairman, the following papers were read:

Host Specificity of a Trematode (Neascus sp.) for Some Freshwater Fishes of New York.—Howard E. Evans, Cornell University.

The Ichthyofauna of the Galápagos Islands.—Richard H. Rosenblatt, University of California, Los Angeles.

The Present Status of Ichthyological Work in the Central Pacific.—William A. Gosline, University of Hawaii.

The Pygmy Whitefish in Lake Superior, With Comments on the Classification of the Whitefishes.—Paul H. Eschmeyer, U. S. Fish and Wildlife Service, and Reeve M. Bailey, University of Michigan.

Effects of an Increase in Population to the Capacity of the Habitat on the Growth and Reproduction of Bairdiella icistius in the Salton Sea.—Richard R. Whitney, University of California, Los Angeles.

Ecology and Management of the Green Sea Turtle, Chelonia mydas.—J. R. Hendrickson, University of Malaya.

Relationships of Salamanders of the Genus Batrachoseps in the Southern Sierra Nevada, California.—Keith F. Murray, California Department of Public Health.

Genetic Effects of X-ray on the Mexican Toad (Bufo valliceps).—W. Frank Blair, University of Texas.

The Skeletal Anatomy of Typhlops.—Howard E. Evans, Cornell University.

Evolution and Zoogeography of the Crotalidae.—Bayard H. Brattstrom, California Institute of Technology.

After lunch, two further papers were presented:

Seasonal Activity of Snakes.—Wilfred T. Neill, Ross Allen Reptile Institute.

Glandular Scales of the Family Sphaerodactylidae, Probable Forerunner of the Preanal and Femoral Pores of the Lizards.—Edward H. Taylor, University of Kansas.

Thereafter, separate sessions were held. DR. GEORGE S. MYERS presided over the herpetological session which featured a symposium that had been arranged by DR. DAVID L. JAMESON, entitled "Problems in the Phylogeny of the Salientia." The symposium, co-sponsored by the Pacific section of the Society of Systematic Zoology, was held in the Student Lecture Room. The following papers were presented:

Introduction and Current Status of Salientian Phylogeny.—George S. Myers, Stanford University.
Phylogeny of the Salientia, Based on Skeletal Morphology.—Bayard H. Brattstrom, California Institute of Technology.
The Role of Gross Morphology in Discerning Salientian Phylogeny.—Charles F. Walker, University of Michigan.
Structure of the Mating Call as an Indication of Affinity in Salientia.—W. Frank Blair, University of Texas.
Phylogenetic Tendencies in Salientian Courtship.—David L. Jameson, University of Oregon.
The Bearing of Larval Evolution on Salientian Phylogeny.—Grace L. Orton, University of California, La Jolla.
The Implications of Chemical Regulation on Salientian Phylogeny.—M. R. Miller, Stanford University.
Distributional Patterns and Salientian Evolution.—Jay M. Savage, Pomona College.

The ichthyological section was presided over by DR. CARL L. HUBBS and was held in the Morrison Auditorium. The following papers were presented:

Some Aspects of the Totoaba Fishery in the Gulf of California.—Julio Berdegué, Instituto Politécnico Nacional de México.
The Genus Trachipterus in the Eastern Pacific.—John E. Fitch, California Department of Fish and Game.
The Evolution of the Clingfishes.—John C. Briggs, University of Florida.
Distribution and Taxonomy of the Percid Fish, Hadropterus nigrofasciatus Agassiz.—Ronald W. Crawford, San Diego State College.
Distribution of the Symphurid Fishes in the Eastern Pacific.—N. Mahadeva, University of California, Los Angeles.
The Distribution and Evolution of the carolinae Species Group of Cottus.—C. Richard Robins, Harrisburg, Pennsylvania.
The Bering Strait Land Bridge and the Zoogeography of Arctic Fishes.—Vladimir Walters, American Museum of Natural History.
Remarks on the Anatomy of Western American Sturgeons.—Vadim D. Vladykov, Département des Pêcheries, Québec.
Discussion of Ichthyological Common Names.—Reeve M. Bailey, University of Michigan.
Ecological Observations of the Genus Neoclinus by Use of Self-contained Diving Apparatus.—Andreas B. Rechnitzer, University of California, La Jolla.
The Spawning of Squid off La Jolla, California.—Conrad Limbaugh, University of California, La Jolla.

In the evening there was a most enjoyable Smoker at the Steinhart Aquarium. In addition to the excellent display of fishes, the members and their guests were treated to an exhibit of living reptiles and amphibians from the western United States. Special demonstrations of the feeding of Archer fish and Angler fish plus examples of experiments to test responses of fishes to electrical fields and temperature were of unusual interest. The appropriate surroundings, the pleasure of speaking to colleagues, and the diverse refreshments all contributed to a most convivial atmosphere.

ACTIVITIES OF JUNE 30

A joint session was held under the chairmanship of DR. BOYD W. WALKER to hear the following papers:

Information From Fish-marking Experiments in the Alaskan Arctic.—Donald E. Wohlschlag, Stanford University.
Serological Systematics of the Family Embiotocidae.—Andreas B. Rechnitzer, University of California, La Jolla.
Homing Response in the Rough-skinned Newt, Taricha granulosa.—David L. Jameson, University of Oregon.
Pacific Species of Lampreys of the Genus Entosphenus.—Vadim D. Vladykov, Département des Pêcheries, Québec.
Amphibians and Reptiles at the San Joaquin Experimental Range.—Walter E. Howard, University of California, Davis.
The Quantitative Analysis of Higher Categories.—Ralph Gordon Johnson, University of Chicago.
Sexual Behavior of Fishes as Observed by Free Diving.—Conrad Limbaugh, University of California, La Jolla.
An Apparently Irregurgitatable Rock from the Stomach of the Snake, Hypsiglena.—Robert Glaser, Museum of Vertebrate Zoology and Sacramento Junior College.

The afternoon session was under the chairmanship of DR. ROLF L. BOLIN. The following papers were presented:

Some Problems in the Comparative Anatomy of Skulls.—Malcolm Jollie, University of Idaho.
The Use of Otoliths as a Taxonomic Aid.—John E. Fitch, California Department of Fish and Game.
Relationships Among the Genera of Centrarchidae.—Theodore H. Eaton, Jr., East Carolina College.
The Morphology of Dorsal- and Anal-Fin Terminations.—Stanley H. Weitzman, Stanford University.
Structure and Development of the Caudal Fin in Teleost Fishes.—E. H. Ahlstrom, U. S. Fish and Wildlife Service.

Following the last paper, the annual business meeting of the ASIH was called to order by PRESIDENT RANEY at 4:30 PM.

The Secretary presented the Treasurer's report, which has now been published in COPEIA, 1955 (3). PRESIDENT RANEY added that DR. GOIN had advised him in a letter that as of June 11, 1955, the Society had $1,495 in the checking account, and it was doubtful whether this would be sufficient to pay the bill for COPEIA No. 2.

A report of the June 27 meeting of the Board of Governors was presented by the Secretary. Two minor changes in the wording of the Constitution, which had been voted by the Governors, were approved by the members.

PRESIDENT RANEY stated that, in the interim since the Governors' meeting, the Society had received a tentative invitation for its 1956 meeting, and asked DR. REEVE M. BAILEY to discuss this. DR. BAILEY said that he understood the American Society of Mammalogists was to meet at Higgins Lake, Michigan and that it was felt it would be desirable if the Society could also hold its meeting there either immediately before or after the Mammalogists. DR. BAILEY suggested two possible meeting places—Ann Arbor, or Higgins Lake which is about 200 miles north of Ann Arbor. He said that dormitory facilities at Higgins Lake would accommodate about 150 people, and that there are motels and excellent camp sites conveniently located in the area. A vote was taken and the majority of

members preferred Higgins Lake. DR. BAILEY said he would investigate the possibilities further. Although no definite date could be set at this time, DR. BAILEY stated it would probably be between June 10 and June 20.

PRESIDENT RANEY said it was hoped to meet in New Orleans and Canada before too long and pointed out that by meeting in different areas each year a number of new members are gained for the Society.

DR. W. I. FOLLETT then presented the Report of the Committee on Zoological Nomenclature, as follows:

During the past year, the Committee on Zoological Nomenclature has taken action on the following matters:

1. A communication from the International Commission on Zoological Nomenclature. requesting advice on the gender to be ascribed to 49 names in Pisces, three in Amphibia, and 10 in Reptilia, which had been place on the Official List of Generic Names in Zoology before 1936. In response to this request, three separate reports were rendered under date of February 15, 1955, one for each of the three classes concerned.

2. A project to determine which, if any, of the herpetological names originally published in Oken's 1816 *Lehrbuch der Naturgeschichte* should be conserved if that work were to be suppressed for nomenclatural purposes. This is the counterpart of the task completed last year by MR. NORMAN J. WILIMOVSKY in connection with Oken's ichthyological names. By unanimous vote of the three herpetological members of the committee, DR. JAY M. SAVAGE of Pomona College was invited to undertake this task. DR. SAVAGE has accepted the invitation.

3. The problem of the name *Ameiurus* versus the name *Ictalurus*, for a genus of catfishes, has come before the Committee by way of a request from the International Commission for the preparation of a Declaration that will state the grounds for rejecting the name *Ameiurus*.

4. The manuscript interpretation of the former Rules, the 1948 Paris enactments, and the 1953 Copenhagen decisions, mentioned in last year's report of the Committee, is now in galley proof and will be completed at the first order of business after the present meetings of the Society.—*W. I. Follett.*

MR. ROGER CONANT reported that his Committee on Traffic in Venomous Reptiles has not been active for two years. MR. CONANT said that after the accident in Springfield, Missouri, a few years ago nothing had been done in regard to controlling poisonous snakes, but he would be glad to pick up the work again if the President wished this to be a standing committee. It was so ordered.

MR. CONANT also reported as Chairman of the Committee on Common Names of Reptiles. He said that several members of his committee had been at the San Francisco meeting, and he thought they had achieved considerable agreement. They hope to be able to prepare a final draft of the list of names within a very few weeks. The question of publication—where and when—is still something that has not been settled. MR. CONANT said that the committee is very active; that it had good meetings in Gainesville; and has worked continuously ever since. He feels that it has settled many of the controversial problems. The committee hopes its results will be accepted as recommendations, not requirements.

PRESIDENT RANEY said that there were two other committees that normally would report. However, the Society had heard a report on the Common Names of Fishes by DR. BAILEY in the form of a formal paper. The President stated he felt it would be unnecessary to call on DR. SUTTKUS for a report on the COPEIA Index, since an Index is already being published privately by one of the members.

The President then asked for a report of the Nominating Committee consisting of DRS. BOYD WALKER, KEN NORRIS, PAUL NEEDHAM, JAY SAVAGE and RAY POOLE. The following officers were duly elected:

Vice-president in Charge of Finance: L. M. KLAUBER
Vice-president of Membership: W. FRANK BLAIR
Vice-president of Conservation: ROGER CONANT
Secretary: ARNOLD B. GROBMAN
Treasurer: COLEMAN J. GOIN
Publications Secretary: N. BAYARD GREEN
Editor-in-Chief: FRED CAGLE
Ichthyological Editor: WILLIAM A. GOSLINE
Herpetological Editor: ROBERT C. STEBBINS
Editorial Board: JOHN C. MARR, ERNEST LACHNER, DAVID L. JAMESON, HENRY FITCH and JAMES OLIVER

Subsequent to the meetings, PRESIDENT RANEY appointed DR. ROBERT R. MILLER to the Editorial Board, in view of DR. LACHNER'S planned absence from the country for several months.

PRESIDENT RANEY expressed regret that the present editors of COPEIA had resigned and complimented them on the excellent job they had done over the years.

SECRETARY GROBMAN reported that the Society now has about 925 domestic, foreign, and life members. Subscriptions number about 350. Over the past few years there has been a slight decline in members and a regular and steady increase in subscriptions to COPEIA. He urged that each member become a committee of one to help make the memberships increase with subscriptions. The Secretary mentioned that the duties of his office included

sending out dues bills (which would now be $6.00 instead of $5.00); processing the dues and subscriptions, and keeping membership rolls intact. He also has to answer inquiries from members and nonmembers. Many of the latter are requests for information about fields of activity in Herpetology and Ichthyology. Since the two committees of the Society (headed by MR. LOREN WOODS and DR. FRED CAGLE) have prepared statements on occupational opportunities, it has been possible for the Secretary simply to send out mimeographed sheets to those requesting such information, which has been very helpful.

The Secretary also pointed out that the Society is in a difficult period of its growth. From a small group of people interested in amphibians, reptiles, and fishes, it has grown to a fairly large professional organization with a good journal, successful meetings, and high professional standards. However, while the officers of a small organization can carry on their duties easily in addition to regular work, and while a large society of three to five thousand members can hire full- or part-time personnel, the ASIH is in an awkward in-between position.

PRESIDENT RANEY thanked the Secretary for the excellent work he has done over the past four years.

DR. FRED STOYE was unable to stay for the business meeting, so DR. CARL HUBBS presented his report on the Revolving Research Fund. DR. HUBBS reminded the members that the Revolving Research Fund is designed to help junior members on various trips and on gaining other objectives in various stages of their careers; it is available for field trips to museums, for purchase ot special equipment or various other professional needs of young members. For a long time the Society bemoaned the fact that the Revolving Research Fund did not live up to its name, in that it was not revolving. Then came a period of requests for grants and those were made. The original plan was to regard these as grants rather than loans; however, the recipients of a grant would be advised that the Society hoped that as soon as the beneficiary received something from his profession and felt able to do so, he would return at least an equal amount. DR. HUBBS said that up till now only two persons have been able to do so. The Fund was established in June, 1946, and by October, 1954, there had been received in contributions from members $1,483.25. However, in response to a recent request in the News Notes, only one contribution of $5.00 was received. There was another contribution of $180. and some unexpended prize monies, so a total of $1,783. has been received for the fund. Ten grants have been made and two repayments of $260. This leaves a present balance of only $435.35. Most of the grants have been small, around $200. There is now only enough in the Fund for but a few additional grants. DR. HUBBS felt it would be unfortunate if the Fund became exhausted, as it has served a good purpose, and he urged that all members consider the possibility of sending the Treasurer a check to build the Fund up again to somewhere near the $1500. or so that was available at one time. He suggested that the Secretary might include a reminder to this effect when he sends out the dues bills.

DR. HUBBS further suggested that members check their local libraries to see if those institutions have copies of the Check List of Amphibians and Reptiles, and if not, ask their librarians to order them.

He also stated that an announcement by PAUL THOMPSON indicated that due to the fact that revisions have not been prepared, the Check List of North and Middle American Fishes, by Jordan, Evermann and Clark, is being reissued and will be sold, bound, at $3.00 and will be available from the Superintendent of Documents, probably in July.

DR. HUBBS has also learned that the supply is low of Berg's "Classification of Fishes, both Recent and Fossil," which was published by J. W. Edwards Publishing, Inc., Ann Arbor, Michigan. He hopes that this can remain in stock because it is one of the most successful general classifications. The price is $6.50 bound, or $5.75 in paper, and it is important to know what demand there may be for this item, particularly in class use or otherwise. DR. HUBBS suggested that if any members could foresee any considerable use for this book they should write to the J. W. Edwards Publishing Company, Ann Arbor, Michigan, to help insure that this valuable treatise will remain in print. [Edward's Brothers have subsequently advised the Editors that Berg's *Classification of Fishes* is being reprinted, cloth bound, price $6.50, and will be ready for distribution in October, 1955.]

DR. HUBBS then said he had one more subject he wanted very much to bring up—the matter of exchange of reprints with Soviet colleagues. DR. HUBBS said that he had been in Europe in both 1953 and 1954 and had met a number of Soviet ichthyologists and fisheries workers and found them almost pathetically anxious to get in touch again with the work being done on this side of the world. He said the contrast in behavior between Russian delegates at the Paris Conference five years ago and at the Copenhagen Congress was very great. DR. HUBBS said outstanding Russian ichthyologists had brought reprints to both the Copenhagen meeting and the Rome meeting, and passed them around. He said that until recently reprints sent by ordinary mail (this did not include exchanges with universities and official institutions) had rarely been received. At present, however, word has come that

packages are getting through and DR. HUBBS has received several packages of Soviet scientists' reprints. He offered to help members of the Society get names and addresses of their Russian colleagues if they wished to take part in such an exchange.

In connection with this suggestion, DR. FOLLETT said he had talked with a representative of the State Department to determine whether there would be any objection on the part of the government to communication with Russian scientists on scientific matters. He learned that, on the contrary, the government is very pleased to have American scientists communicate with those of Russia about matters in their field.

After reminding members that there would be a meeting of the Western Division immediately after the business meeting, PRESIDENT RANEY adjourned the meeting.

The Annual Banquet was held at the A. Sabella Fish Grotto, Fisherman's Wharf, at 7:30 PM. After the banquet several motion pictures were enjoyed by the assembled members and guests.

Two prizes were awarded for ichthyological papers. First prize of $25. was awarded to GEORGE W. BARLOW, of the University of California at Los Angeles, for his paper "Ecological Aspects of the Behavior of *Cyprinodon macularius* in the Salton Sea." The second price of $12.50 was awarded to JAY C. QUAST of the University of California at Los Angeles, for his paper "Food Selectivity by the Gulf Croaker in the Salton Sea."

DR. HUBBS, Chairman of the Resolutions Committee, then presented the following resolutions which were unanimously adopted:

1. WHEREAS, the members of the American Society of Ichthyologists and Herpetologists, at their 35th annual meeting, hear of the recent illness that has befallen COLEMAN J. GOIN,

THEREFORE BE IT RESOLVED, that our greetings and very best wishes for a speedy and complete recovery be carried by the Secretary to our good friend and efficient Treasurer.

2. WHEREAS, the members of the Board of Governors and their families were most graciously entertained at dinner at the Cliff House prior to the meetings,

THEREFORE BE IT RESOLVED, that our heartiest thanks and appreciation be given to DR. and MRS. WILLIAM I. FOLLETT, hosts for this delightful occasion.

3. WHEREAS, there exist in the West many unique kinds of fishes, amphibians, reptiles and other animals whose very limited habitats and whose very existence are threatened by the current eruption of the human population in the region, and

WHEREAS, each of these relict animals possesses such great scientific and educational value that its extinction would be a tragic loss, inconsistent with the rightmindedness of the American people,

THEREFORE BE IT RESOLVED, at this its thirty-fifth annual meeting, at San Francisco, on June 30, 1955, that the American Society of Ichthyologists and Herpetologists reaffirm to the national and state park agencies and to other organizations and individuals concerned, that all possible steps be taken to maintain such creatures and their natural habitats.

SPECIFICALLY, at this time, we refer to:

(1) The several hot and warm springs now within or possibly to be added to the Death Valley National Monument, for their limited waters harbor endemic kinds of fishes, insects, and other aquatic animals known nowhere else and incapable of continued existence under threatened resort development;

(2) The marshy area of Mission Bay, in San Diego, that has been recommended and planned as a wildlife sanctuary by staff members of the Fish and Wildlife Service, the California Department of Fish and Game, and local educational and scientific institutions;

(3) The small areas at Briceburg, Mariposa County, and near Aptos, Santa Cruz County, California, the only known habitats of two relict and distinctive kinds of salamanders. The Briceburg locality should be protected against excessive collecting and the Aptos site is threatened by real estate developments.

4. WHEREAS, the publication of COPEIA has long been the most effective factor in the growth and activities of the American Society of Ichthyologists and Herpetologists, and has contributed most significantly to the advancement of ichthyology, herpetology, and biology in general, and

WHEREAS, during a long period, each member of the retiring editorial staff has generously, faithfully, and effectively fulfilled his respective function in such a way that the high standards of the journal have not only been maintained but raised, and its size, usefulness, and reputation markedly expanded,

THEREFORE, BE IT RESOLVED, at this, the thirty-fifth Annual Meeting, that in deep gratitude the members of the Society, individually and collectively, extend to GERALD P. COOPER, Editor-in-Chief, to ROBERT RUSH MILLER, Ichthyological Editor, and to NORMAN E. HARTWEG, Herpetological Editor, this greeting:

VERY WELL DONE, AND MANY THANKS.

5. WHEREAS, the members of the American Society of Ichthyologists and Herpetologists attending the 35th annual gathering of the Society, and the 24th of the Western Division, feel that this meeting has been one of the most excellently conceived and one of the most ably handled, as well as

one of the most stimulating and pleasant in the history of the Society, now

THEREFORE, BE IT RESOLVED, that our congratulations and deep gratitude be hereby expressed to W. I. FOLLETT and each member of his local committee; to our host institution, the California Academy of Sciences and to Stanford University and to their staff members concerned; to MR. and MRS. FRANK SPENGER, SR.; to the California Department of Fish and Game; and to all other individuals and organizations, including the efficient officers of the Society, for the parts they have respectively played in planning and executing this outstanding meeting. Particularly appreciated were the special fish exhibits and Smoker at the Steinhart Aquarium, arranged by EARL S. HERALD, and the remarkably complete exhibit of California amphibians and reptiles, collected by ROBERT C. STEBBINS and associates.

ACTIVITIES OF JULY 1

A group of 60 members and friends of the Society left from the Whitcomb Hotel by bus and private cars at 8 AM and drove to the Muir Woods National Monument, where they spent an hour examining the biota typical of a coastal redwood grove. Thereafter the group divided, the herpetologists, led by DR. ROBERT C. STEBBINS, proceeding to the vicinity of Tomales Bay State Park, where (outside the Park boundaries) they collected 26 amphibians and reptiles of half a dozen species. The ichthyologists led by DR. PAUL R. NEEDHAM, proceeded to Youngs Landing on Tomales Bay, where a 700-foot beach seine was set by MR. FRANK SPENGLER, SR., and his associates, and was pulled ashore by most of those in attendance. A large number of fishes, comprising 33 species, were thus collected and many of these were preserved by the representatives of several institutions. The motor vessel NAUTILUS, of the California Department of Fish and Game, was in drydock, and for this reason it was impossible to conduct the beam-trawling operations that had been planned. At 4 PM all participants in the field trip became the guests of MR. and MRS. FRANK SPENGER, SR., at a cioppino supper featuring fish, crabs, prawns, and rock cockles.

ACTIVITIES OF JULY 2

A total of 46 persons signed the register at the Natural History Museum, Stanford University, where there was an extensive display of the containers used by a number of museums, as well as caps, liners, labels, tags, data sheets, and other field and museum equipment. Also on exhibit were rare items from the older literature, and group photographs of former ASIH meetings. The newly installed metallic shelving of the alcoholic collections, and the recently completed quarters of the George Vanderbilt Foundation, attracted much attention. During the evening a Fischundherpverein was held at the home of DR. and MRS. DONALD E. WOHLSCHLAG.

ACTIVITIES OF JULY 3

Twenty-eight persons, of whom a number traveled the 130 miles from San Francisco, attended the Open House at the Hopkins Marine Station at Monterey Bay. On display were lanternfishes and live invertebrate representatives of the local fauna, as well as oceanographic collecting equipment and physiological instruments. The affair was climaxed by a garden party at the home of DR. and MRS. ROLF L. BOLIN, overlooking the lower Carmel Valley.

The meetings were among the most successful the Society has ever held. The number of papers presented was greater than at any previous meeting. While the great bulk of the papers were ichthyological, it is of interest to note that it was two herpetological papers that were selected by *Newsweek* for coverage in its columns the week following the meetings.—ARNOLD B. GROBMAN, *Secretary*.

C. B. PERKINS

1889 – 1955

C. B. PERKINS, 66, one of America's leading herpetologists and for 24 years in charge of the Reptile Department, San Diego Zoo, died April 28, 1955. Under his direction the snake house had been developed into one of the world's outstanding collections.

SI PERKINS was born in Denver. He first visited San Diego when he was a lieutenant in the Navy Air Corps during World War I. He was a stock broker and banker in Denver. During later visits here he became interested in the Zoo and in 1928 became a member of the San Diego Zoological Society. Three years later, he was placed in charge of the reptiles.

He attained an outstanding reputation for his success in breeding and rearing reptiles in captivity and for promoting the longevity of captive snakes. The Zoo has had one cobra more than 26 years. Of the 21 known cases of rattlesnakes born in captivity, Zoo records show 18 were born during SI PERKINS' regime. Of the 65 known cases of snakes of any variety born in captivity, 35 were at the San Diego Zoo.

He participated in several expeditions to gather reptiles and other specimens for the Zoo, visiting the Galapagos Islands, the Dutch East Indies and South America. Among his published works his "A Key to the Snakes of the United States" is the best known and is a textbook in many schools.

He is survived by his widow, LILIAN STEARNS PERKINS, of 4560 55th St.; two daughters, MRS. ROBERT MOODY and MRS. CHARLES WIDDECKE, San Diego; and a son, CYRUS STEARNS PERKINS, Albuquerque, N. M. Private services were conducted at Greenwood Mortuary, San Diego.—WALLACE B. WADE, *San Diego Zoo, San Diego, California.*

Fish work in Hawaii

IN July, 1955, MR. O. E. SETTE resigned as Director of the Pacific Oceanic Fishery Investigations (P.O.F.I.) in order to head a new U. S. Fish and Wildlife Service investigation at Stanford University into the relationship between climatic change and the fluctuation in world fisheries. He took up his new duties in September. Replacing him as Director is DR. A. L. TESTER, formerly Professor of Zoology at the University of Hawaii. The program at P.O.F.I. includes much basic as well as applied research related to the Central Pacific tunas.

The Territorial Division of Fish and Game, headed by MR. V. E. BROCK, is chiefly concerned with the inshore and freshwater fisheries of Hawaii. The division is a research as well as a management agency. Available basic research time is largely applied to an investigation of the relationships between the more important reef fishes and their environment.

At the University of Hawaii, DR. F. E. J. FRY will fill DR. TESTER's former position for the academic year 1955–56. DR. FRY is on a year's leave of absence from the University of Toronto. Recent recipients of the Doctor's Degree at the University of Hawaii are D. W. STRASBURG (1953) and J. E. RANDALL (1955). DR. STRASBURG, after two years at Duke University, has taken a position at P.O.F.I. His doctor's thesis, now partially in press, was on "The Comparative Ecology of Two Salariin Blennies." DR. RANDALL has received a one-year, postdoctoral, Yale-Bishop Museum fellowship to study certain reef fishes in Tahiti. His Ph.D. thesis on the biology of surgeon fishes (Acanthuridae) includes a world-wide revision of most of the family, and is now in press.

Gift to Copeia

THE Society acknowledges with thanks the receipt of a gift of $250 toward the cost of printing COPEIA 1955, No. 3, containing the article on a new lamprey by V. D VLADYKOV. The gift was made by the HONOURABLE CAMILLE E. POULIOT, M.D., Minister of the Quebec Department of Game and Fisheries, on behalf of his Department.

1956 annual meeting

THE 1956 annual meeting of the ASIH will be held at the Michigan Department of Conservation's Higgins Lake Training School, located just east of Roscommon, Michigan. DR. REEVE M. BAILEY is Chairman of the Local Committee. The dates are June 20–24. The American Society of Mammalogists meets at the same school, departing on June 20.

News Notes

THE retiring editors wish to express publicly their gratitude to WILLIAM L. BRUDON, Staff Artist of the Museum of Zoology, University of Michigan, and to WILLIAM L. CRISTANELLI, Graphic Designer of the Institute for Fisheries Research, Michigan Department of Conservation who, over the past 5½ years, have generously assisted in the final preparation of many of the illustrations that have appeared in COPEIA.

WILLIAM A. DILL, Senior Fisheries Biologist of the California Department of Fish and Game, has been appointed as head of all freshwater fisheries biological work for the United Nations Food and Agricultural Organization. His new address is: Fisheries Division, Biology Branch, Food and Agricultural Organization of the United Nations, Viale delle Terme di Caracalla, Rome, Italy.

Notice has been received that the possible use by the International Commission on Zoological Nomenclature of its Plenary Powers is involved in the following applications, both of which have been published. (1) *Sphenodon* Gray, 1831, validation of emendation to, from *Sphaenodon*; Sphenodontidae Cope, 1870, validation of. 1955, Bull. Zool. Nomen., 11(5): 139–41. Code Number Z.N.(S.)811. (2) *Desmognathus* Baird, 1850, and *Syngnathus* Linneaus, 1758, determination of a gender in harmony with accustomed usage. Ibid., 11(8): 260–2. Code Number Z.N.(S.)942. Interested specialists should present their views promptly to the Secretary of the International Commission on Zoological Nomenclature, MR. FRANCIS HEMMING, 28 Park Village East, Regent's Park, London N.W. 1, England.

DRS. CLARENCE F. DINEEN and PAUL S. STOKELEY have been awarded a grant by the American Academy of Arts and Sciences to support their studies on the comparative osteology of the sunfish family Centrarchidae.

MR. RICHARD H. STROUD has been promoted to the post of Executive Vice-President of the Sport Fishing Institute to fill the vacancy created by the passing of R. W. ESCHMEYER. MR. GEORGE S. FICHTER, recently Editor of *The Fisherman* magazine, has been appointed Assistant Executive Vice-President.

DR. REZNEAT M. DARNELL, of Tulane University, completed his ecological studies of Lake Pontchartrain and is now on the staff of Marquette University.

DR. JOHN E. BARDACH has received a grant from the National Science Foundation to pursue a fishery program in Bermuda.

Word is received of the death on April 7, 1955 of WILLIAM RAY ALLEN, Professor of Zoology, University of Kentucky, and a member of the Society. PROF. ALLEN had been in poor health for several years.

The 1930 "Check List of the Fishes and Fish-like Vertebrates of North and Middle America North of the Northern Boundary of Venezuela and Columbia" by Jordan, Evermann, and Clark, which has been out-of-print for many years, is being reprinted in its original form. Supply limited, price $3.00, Superintendent of Public Documents, Washington, D. C.

The Society-owned set of COPEIA, bound through 1951 and complete to date, which is in custody of the Editor-in-Chief, was turned over to FRED R. CAGLE during September, 1955.—G. P. C.

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